

Transitional Spaces: Between Indoor and Outdoor Spaces

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Abstract. Traditionally, spaces have been classified as being located either indoors or outdoors. On closer inspection, however, this distinction is not as clear cut as usually assumed. For example, when navigating complex urban landscapes, pedestrians frequently traverse tunnels, enclosed footbridges or partially roofed courtyards. In this paper, we investigate this type of spaces between indoor and outdoor areas. We present an initial definition of transitional spaces based on a conceptual analysis, and then report on results from an empirical study with 103 pedestrians, whom we interviewed in an urban area. A statistical and linguistic analysis of the outcomes of the study provides evidence for the existence of transitional spaces and their use. The outcomes also support an initial set of characteristics and properties that further clarify these areas. The results pave the way for the further investigation of transitional spaces, e.g. in terms of providing effective navigation support through them.

Keywords: transitional spaces, navigation, urban areas.

1 Motivation

Urban spaces can be quite complex to navigate, in particular for people who are not familiar with certain areas of a city. The structure and fabric of cities and their use has therefore been an active area of research for many years [20]. While this has led to a better understanding of how people navigate in general, how we can support this and what elements might be relevant, the problem can still not be considered to be solved. Even when equipped with modern context-aware guide applications people still frequently struggle with the task of navigating urban areas. One reason for this is the complex and dynamic nature of urban landscapes, which include indoor areas and outdoor areas, can be very crowded, and are also subject to access restrictions and temporary changes.

Previous work has investigated how people understand and navigate indoor areas or outdoor areas [5,11], and into how they negotiate routes that cross indoor and outdoor spaces [3]. However, the simple distinction between indoor and outdoor spaces may not be sufficient to describe all areas found in complex urban environments. Arcades, transportation hubs, foot tunnels or partially roofed

open spaces are examples for areas, which illustrate that this dichotomy might not quite suffice to adequately capture all phenomena found in urban areas. Such *transitional spaces* share properties with both indoor and outdoor spaces but so far have not been analyzed more thoroughly. Since indoor and outdoor spaces differ significantly in a number of ways – for example, in terms of how people navigate these spaces and how they describe routes through them – transitional spaces may constitute a source for confusion when navigating urban areas. In this paper we therefore take a closer look at the different types of areas people traverse when moving about in cities, and we focus in particular on those spaces that may not be easily classified as either being indoors or outdoors. Our goal was to characterize transitional spaces, to gather initial evidence whether for human users of urban spaces such areas differ considerably from indoor and outdoor areas, and to gain an initial understanding of how people describe routes traversing transitional spaces.

The following section reviews related work in this area, which informs a conceptual analysis of what characterizes transitional spaces. In section 4, we present an overview of the methodology we used to further investigate transitional spaces. The three types of analysis we carried out are then reported on in the following sections. Section 8 reviews the results we obtained, discusses limitations of our study and points out implications of the outcomes. The paper closes by summarizing our main contributions and highlighting areas for further research.

2 Related Work

A large number of people move about in urban environments every day for a variety of reasons, e.g. when going to work, carrying out touristic activities, or when pursuing leisure activities [9]. These seemingly mundane activities can actually be quite challenging, i.e. when faced with unknown areas, and may require people to negotiate a highly complex environment. Frequently, pedestrians navigating city spaces traverse areas located outside buildings (e.g. pavements, parks and so on) and spaces, which are considered parts of building interiors (e.g. shops or public buildings). In addition, they also pass through multiple levels and zones, which are difficult to classify as being either indoors or outdoors, such as arcades, malls or roofed footbridges.

Indoor and outdoor spaces are commonly considered to considerably differ in several ways. Firstly, indoor environments such as buildings tend to have a smaller size than outdoor environments. Conceptually, size has been an important differentiator between different types of spaces. For example, Downs and Stea categorized space into *small-scale perceptual space* or *large-scale geographic space* [7]; a similar distinction has been proposed by Montello [22]. A second key difference distinguishing indoor and outdoor environments is dimensionality. Frequently, indoor environments (buildings) enable people to move between different floors or levels whereas this is usually not the case for outdoor spaces. Indoor environments thus are usually classified as being three-dimensional (or at

least 2.5-dimensional) spaces unlike commonly two-dimensional outdoor environments. This additional vertical dimension can considerably contribute towards greater cognitive loads when negotiating indoor spaces [12]. Staircases, for example, have the potential to not only negatively affect people's sense of orientation but can also cause problems for systems meant to support navigation [19].

A third relevant difference relates to the use of landmarks, e.g. in order to facilitate wayfinding. Typical landmarks inside interior spaces differ from typical landmarks in outdoor environments. Due to the limited field of view in indoor environments, some useful landmarks available in outdoor environments such as the sun, mountains or water bodies, cannot be seen while inside buildings. Consequently, it is predominantly local landmarks that can be used for indoor wayfinding, while wayfinding in outdoor environments has the flexibility to rely on both global (e.g. skylines or sun) and local landmarks conveniently [25]. A fourth difference stems from the built nature and structure of indoor environments. Walls, doors and other obstacles making up the fabric of indoor spaces restrict movement whereas outdoor environments frequently enable people to move freely in all directions. A beneficial side effect of the constructed nature of indoor environments is that wayfinding is not affected by weather conditions, which can have a considerable impact on wayfinding in outdoor environments. Finally, the line of sight inside buildings is usually much more constrained than in outdoor spaces.

In summary, indoor and outdoor spaces are usually considered to be quite different in terms of their structure and properties but also in terms of how people perceive and navigate them. Signage, for example, may play a more prominent role in indoor environments than it does in outdoor spaces [8], whereas directions based on cardinal directions clearly are more useful in outdoor environments. Consequently, these aspects should be taken into account as well when generating directions to support people navigating such areas [16,23]. Urban areas are, however, complex structures [20] comprising not only indoor and outdoor areas but also some locations, for which it may be difficult to decide whether they are indoors or outdoors (e.g. shopping malls, arcades and underpasses). Such spaces might share properties of indoor and outdoor areas [24], and include multiple traversable levels [11], each of which may be classified differently in terms of whether it is indoors or outdoors.

Frequently, urban navigation entails traversing both indoor and outdoor environments, and transitioning between indoor and outdoor areas holds considerable potential for confusion and loss of orientation [8,13]. Early approaches to support wayfinding often focused on outdoor navigation [5] but more recent work in this area frequently investigates navigation assistance for people moving inside buildings [23,2,19]. In comparison, only very few approaches have been proposed that integrate navigation of indoor and outdoor areas [3,15]. Since people perceive indoor and outdoor areas differently, and since their navigation strategies may vary as well [8], planning routes that span both types of spaces can still be considered a significant challenge [4].

On a technical level, this issue also poses challenges in terms of integrating different representations of indoor and outdoor areas. While there are standards and approaches to model urban areas [10] and indoor environments [14,21] as well as ways to infer 3D information from existing representations [6,18], connecting these models, e. g. to enable seamless route planning, is still difficult [4]. A particular challenge relates to those areas that are neither indoors nor outdoors. These *transitional zones* are not well understood, neither in terms of how to represent them, nor in terms of how people navigate through them or how they describe routes traversing them. A related issue is the actual transition between indoor and outdoor spaces, which poses several challenges: it is not always clear when one type of space has been left and another one has been entered, e. g. in case of partially covered areas such as arcades or underpasses [24]. Given the different nature and navigation behavior in both types of spaces, this uncertainty can also contribute to orientation- and navigation-related problems pedestrians face in urban areas. These observations are further reasons to consider the introduction of transitional spaces on the conceptual and technical level.

3 Transitional Spaces

Based on the discussion in the previous section and on some of the criteria mentioned therein, it makes sense to more systematically contrast indoor and outdoor spaces. Such a comparison will also provide a starting point for the characterization of transitional zones as they might share certain properties of both indoor and outdoor areas, or exhibit distinct characteristics different from indoor/outdoor spaces. The previous section already briefly discussed some examples of transitional zones but in order to arrive at a working definition of such spaces and to support the identification of comparison criteria, a more detailed analysis will be useful.

When looking for such examples, several potential candidates quickly emerge. Shopping malls often combine indoor and outdoor areas as well as areas, which are roofed but are not fully enclosed. In addition, they can serve as a frequently used passage or shortcut from one part of the city to another. As shopping centers can have a considerable spatial extent – e. g. a city block – it may be faster and more convenient to traverse them instead of circumventing them, in particular in adverse weather conditions. Foot tunnels and underpasses constitute further examples for such spaces. They share characteristics with outdoor environments such as footpaths or streets while at the same time being completely enclosed and being man-built. They have a linear structure with horizontal extent, but usually little or no vertical extent, which characterizes many indoor environments. They offer partial protection from weather conditions (i. e. precipitation) but not from others (i. e. wind, temperature). Similar properties are shared by roofed footbridges, which are found in many large cities, where motorways have to be crossed by pedestrians.

A further example are arcades, which are common in many cities – in particular where pedestrians require protection from weather conditions such as

frequent rain or very hot temperatures. Arcades are usually roofed and surrounded by walls on one or more sides but frequently not separated at all from outdoor environments. They may share the same pavement as adjacent walkways or streets, and pedestrians can easily exit them to indoor or outdoor areas at any point. Similar to tunnels or underpasses, arcades are often publicly owned and everyone has access to them at any time. In this respect, shopping malls differ slightly since they are usually owned by a company and have specific opening hours, though in practical terms the difference is often small as anyone can walk through a mall during most of the day.

Transportation hubs such as train stations, airports or metro stations are subject to similar access restrictions, i. e. they have specific opening times and are not fully public. They also often include areas, which could be classified as either indoor or outdoor areas, as well as some spaces, which may be difficult to place in either category. For example, the roofed areas near the tracks at a train station could be considered part of the train station itself (and thus as being indoors) or could be construed of as being outdoors (since they are not fully enclosed). Signage plays an important role in such hubs [8], which is partially due to the inherent homogeneity or symmetry. Tracks or gates are usually labeled following a predefined logical rule set, and these labels are used throughout a transportation hub to support wayfinding. Explicit landmarks frequently either do not exist or if they do (e. g. a unique feature such as a specific shop or piece of art), are not commonly used for directions.

Other aspects to consider when analyzing transitional spaces include the function of those areas, the typical duration a person remains in those areas, and the number of people ‘using’ the space. Here, we can observe that a large number of the examples discussed above share some properties: many of them are not intended for people to remain in them for extended periods of time, and they often do not constitute a destination of their own right – tunnels, raised walkways, and transportation hubs fall into that category. Shopping malls and (to a lesser degree) arcades can also be understood in such a way. However, people do tend to spend more time in these places and also specifically go there, e. g. in order to buy things or to meet up with friends. A characteristic shared by almost all the examples discussed so far is the number of people using these transitional spaces: frequently, these areas are very busy and many people pass through them during the day.

Table 1 summarizes the criteria discussed in the previous paragraphs, and contrasts indoor, outdoor and transitional areas using those criteria. The list of criteria and the typical values associated with each category is based on an analysis of several example sites (such as the ones discussed above or the ones used in study). The set of criteria and values were discussed at a series of meetings of the researchers involved in this project and went through a number of iterations until stable. The table lists typical values observed for each type of space for each category. It is worth pointing out that for each category it is also possible to find examples, which differ from the typical values reported in the table. For example, a small courtyard garden as found in some traditional

Japanese homes, could be considered to be indoors despite not having a roof. This example also highlights the potential for the influence of cultural aspects on what is perceived as being a transitional space. Our initial investigation focused on European settings.

We also used the criteria listed in table 1 to select locations for our survey study, which we report on later on in this paper. Based on this discussion, we can also propose a working definition for the concept of transitional spaces.

Transitional spaces can be defined as spaces that can be neither consistently classified as being indoors nor being outdoors and that share properties with either category. Transitional spaces are generally located between indoor and outdoor spaces.

This definition can serve as a starting point to gain a better understanding of transitional spaces, and to investigate their properties and uses. The following sections describe how we approached the topic and what results we obtained.

4 Methodology

In order to take into account the complex nature of transitional spaces and to gain a deeper understanding of them, we followed a three-pronged approach combining a qualitative site analysis, an empirical study and a linguistic analysis. In doing so, we tried to obtain evidence for the existence of transitional zones and to gain a deeper understanding of their properties, nature and use.

The *site analysis* was based on our working definition of transitional spaces and the criteria we identified in the previous section. We reviewed a number of sites using these criteria to see whether they would confirm our initial observations regarding the properties of transitional zones. Additionally, we were interested in seeing whether we would indeed find examples for such zones. Finally, this analysis also provided us with a number of candidate sites, which we could then use in a user study to gather direct feedback from pedestrians.

We then carried out an *exploratory survey study* in a city center in order to get direct input from people who are using these spaces. Since the transitory nature of transitional spaces seemed to be a relevant factor, the study specifically looked into how people navigate and describe complex urban environments, which include transitional spaces. We interviewed 103 pedestrians in the city center of Hanover, Germany. During the interviews, we asked them to describe short routes through the city, which included areas that were good candidates for transitional zones. We also asked them directly to characterize several locations/decision points in terms of whether they would consider them indoors or outdoors. In addition to classification data, the study also resulted in a number of route descriptions that covered transitional spaces. This body of linguistic data provided a further means to analyze the characteristics of transitional zones.

The third step of our methodology was thus a *linguistic analysis* of the route descriptions given by the participants of the survey study. We specifically investigated which spatial expressions (including but not limited to prepositions) they

Table 1. Comparison of indoor, outdoor, and transitional spaces: typical values observed for a number of key properties

	outdoor	indoor	transitional
access	often unrestricted	usually regulated, gated	varying: unrestricted / regulated, often gated
traversal	usually free movement	often along defined paths	mainly along defined paths
landmarks	global / local	mainly local, signage important	mainly local, signage may be important
line of sight	often unobstructed	usually limited	usually limited
function	varying	varying	often traversal, waiting
enclosure	usually none	usually fully enclosed	usually partially enclosed
protection from elements	usually none	often complete	usually partial
length of stay	varying	varying but often long	frequently short
frequentation	varying	varying	often busy
dimensionality	usually 2D	often 2.5 to 3D	often essentially 2D
ownership	often public	usually non-public	mainly non-public

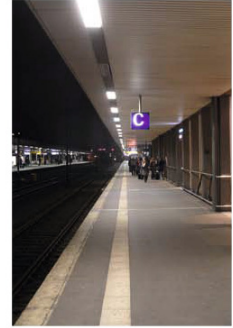
were using when referring to different locations along the routes. Our goal here was to see whether indoor, outdoor and transitional spaces are described in the same way or whether there were systematic differences. Additionally, we were interested in finding out whether the linguistic data confirmed or contradicted the direct classification that we had obtained from participants.

The following three sections report on the details of how these three steps were implemented and what results we obtained. The penultimate sections interrelate the results, discuss implications and point out limitations of our approach.

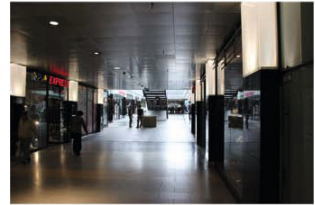
5 Site Analysis

The definition given in section 3 locates transitional spaces between indoor and outdoor spaces and also characterizes them along several dimensions. Based on these considerations we reviewed urban areas in Northern Germany in order to identify areas that might qualify as transitional spaces. Using photographs, virtual globes and other sources, we looked at locations such as shopping malls, transportation hubs, event locations, or sites combining these functions. We were particularly looking for inner city locations, which contained several transitional spaces within walking distance, so that a study investigating them with actual

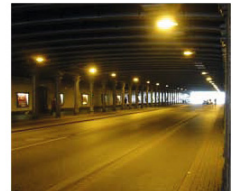
central station



Passarelle



Posttunnel



Raschplatz



Fig. 1. Photographs of the four sites we analyzed: the central station, the Passarelle, the Posttunnel, and the Raschplatz

users would be feasible. The area around the central station in Hanover proved to be well suited, as it contained multiple candidate sites, which were in close vicinity to each other, and which could also support a study in the area. In the following paragraphs, we review four of these sites, which could be classified as being transitional zones: the central station of Hanover, the Passarelle¹, the Posttunnel, and the Raschplatz.

¹ The official name for this shopping area is "Niki-de-Saint-Phalle-Promenade", which it was given ten years ago. Most people still refer to it using its old name "Passarelle".

The *central station* is at the center of the area, around which the other sites are located. With more than 600 trains and 250,000 persons passing through it per day² it is a busy and highly frequented site. In addition to its function as a transportation hub, the station itself also serves as multi-story shopping center. On the basement level, it connects to the *Passarelle*. This shopping arcade in a former subway tunnel consists of a single story linear structure below street level. For most of its length, it is upwardly open (i. e. there is no roof). It provides access to the central station, which is located at one end of the *Passarelle*, and to the ground-level pedestrian precinct through staircases and escalators. As part of a bigger continuous pedestrian area with a total length of about 2500m it sees a lot of foot traffic throughout the day. The *Posttunnel* is a 150m long tunnel-like underpass underneath the railway tracks next to the central station. It is frequented by cars, busses and bikes as well as pedestrians, and it connects major streets on both sides of the central station. The *Raschplatz* plaza is situated behind the central station. This open space is at the same height level as the basement level of the central station. One side connects to the continuation of the *Passarelle* through the central station, the other sides provide access to ground level via staircases.

Figure 1 shows photographs of the four sites we analyzed. Table 2 summarizes our evaluation of each site with respect to the comparison criteria described in section 3. (Property values might correspond to more than one category.) The analysis followed an iterative approach similar to the one used in the elicitation of the criteria in section 3. Specific values were discussed in a series of group meetings until a consensus was reached. In the table, property values are set in different typefaces: values corresponding to outdoors spaces are in bold, those relating to indoor spaces in italics, and values corresponding to transitional spaces are underlined. Combinations of these typefaces (e.g. bold and underlined) indicate values that can represent different types of spaces (e.g. outdoor and indoor spaces).

The table highlights a number of aspects. Firstly, we can observe that neither site is uniquely classifiable as a particular type of space. Secondly, it is also obvious that the *Raschplatz* shares many properties with outdoor spaces but only very few with indoor and transitional spaces. Thirdly, central station, *Passarelle* and *Posttunnel* each score highly in terms of properties shared with transitional spaces. Finally, we can see that while the latter three sites have a similar distribution of shared properties across the three types of spaces, the actual values in each category vary considerably. In summary, we can thus conclude that except for the *Raschplatz* all the sites analyzed in this section could be classified as transitional spaces according to our definition and the criteria we specified. In order to confirm these findings, we used these sites to gather direct feedback from users of the identified transitional spaces in the context of an empirical study.

6 Empirical Analysis

In September 2012, we carried out interviews at two different locations in the city center of Hanover. Both locations were in the pedestrian zone near the

² Source: <http://www.bahnhof.de/#station/18705>, accessed March 10th, 2013.

Table 2. Classification of the chosen sites in Hanover according to Tab. 1: properties found in **outdoor spaces are bold**, *indoor properties are italic* and transitional properties underlined; multiple categorization are possible. The three bottom rows reflect the number of properties shared per type of space for each site.

	Central Station	Passarelle	Posttunnel	Raschplatz
access	<u>semi-restricted</u> (<u>valid ticket zones</u>)	staircases, escalators, unrestricted	unre- stricted	staircases, unrestricted
traversal	<u>multiple defined</u> <u>paths</u>	<u>one path</u>	<u>one path</u>	free move- ment
landmarks	<i>local, signage</i>	<u>local, signage</u>	<u>local</u>	<u>global, signage</u>
line of sight	<u>limited</u>	<u>limited</u>	<u>very limited</u>	rather un- limited
function	shopping, commuting, waiting	<u>shopping</u>	<u>traversal</u>	<u>traversal, plaza</u>
enclosure	complete (ground level), partially (tracks)	partially open air, <u>underground</u>	<i>tunnel</i>	almost none
protection from elements	full (ground level), <u>partially (tracks)</u>	<u>partially</u>	<u>protection</u> <u>from rain</u> but windy	no protec- tion
length of stay	<i>varying</i>	<u>short</u>	<u>short</u>	<i>varying</i>
frequentation	<u>busy</u>	<u>busy</u>	<u>varied</u>	<u>varied</u>
dimensionality	<i>3D</i>	2D	2D	2D
ownership	<u>non-public</u>	<u>non-public</u>	public	public
outdoor	2 properties	3 properties	3 properties	10 properties
indoor	7 properties	4 properties	4 properties	2 properties
transitional	8 properties	9 properties	7 properties	3 properties

central station at junctions of highly frequented shopping streets. During the course of one day we interviewed 103 participants, who we approached opportunistically. The demographic characteristics assessed were gender, age group, familiarity with the city of Hanover and the familiarity with the city center. The age distribution spans a broad range from teenagers to elderly people with a high numbers in the twenties and low numbers in the forties as illustrated in Figure 2. The graphics also shows that the number of female participants is slightly larger than the one of male participants (overall 57% female, 43% male).

Familiarity was assessed on a five-level Likert scale ranging from 1 ‘very familiar’ to 5 ‘not familiar at all’. The familiarity with the city of Hanover in general

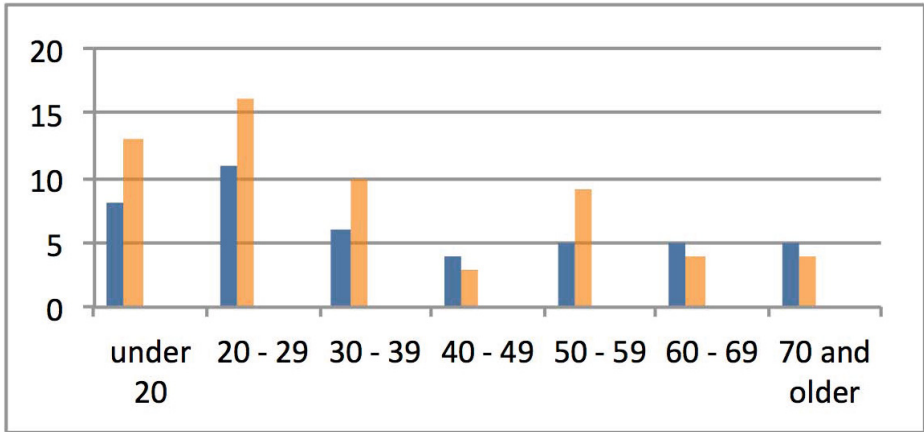


Fig. 2. Age and gender distribution of the participants. Blue bars (left) indicate males, orange bars (right) indicate females

was on average 2.7 (median: 3) and for the city center on average 2.24 (median: 2). After having collected demographic information, we asked participants to provide us with route descriptions for a pedestrian route from the interview location (denoted as B and C, cf. Figure 3) to a destination (denoted as A, cf. Figure 3) behind the central station, which was well known to the citizens. The routes had an approximate length of 700 m and 1100 m respectively. The descriptions were provided orally and we transcribed them manually in parallel. The last part of the interview consisted of a classification task for the four nearby sites presented in the previous section. The participants had to place each location on a five-level Likert scale with the values “indoors”, “rather indoors”, “neither nor”, “rather outdoors”, “outdoors”. As the four locations were nearby but not directly visible from the interview location we presented participants with a collection of several photographs for each site, showing different aspects and being taken from different perspectives.

Figure 3 (a) shows an overview of the study area, which contains the four sites under investigation. The sites are labeled in the figure as well as color-coded according to the color scheme depicted in Figure 3 (b). In addition, subfigure (a) also shows the routes described by the participants, which are color-coded according to the scheme shown in subfigure (c). The thickness of lines shown in subfigure (c) indicates how often a specific option was chosen by participants: the thicker the line, the more frequently it was chosen. The two main levels are depicted by the grey 3D objects – the ground floor is shown over the satellite image at the top, and the basement level is shown below.

Several key observations emerged when analyzing the information we gathered during the study. Figure 3 (b) highlights a strong disagreement between participants with respect to where to place the four sites under considerations. Whereas for the central station and the Raschplatz there clearly was a preferred category (i. e. outdoor area), this was not true for the Passarelle and the

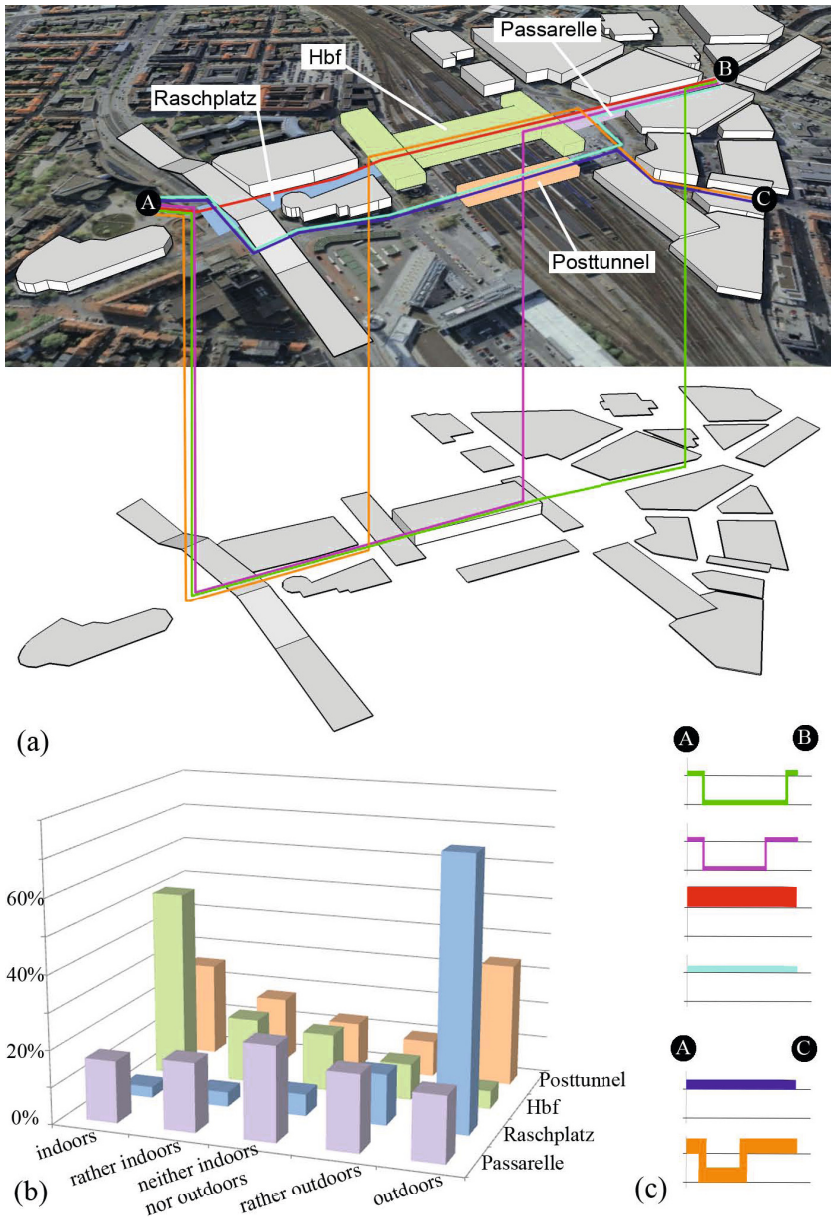


Fig. 3. Outcome of the empirical analysis characterizing the four sites in terms of being indoors or outdoors (b), also visualizing the height profile (c) and the trajectories (a) of the routes based on the directions given by the participants. Locations and routes are color-coded and labeled in subfigure (a) and the same coloring and labeling scheme is used in the diagrams (b) and (c)

Posttunnel. The central station was categorized as being an indoor area by about 50% of the participants; the remaining 50% of the votes were distributed over the other choices. Numbers decreased with the degree of “outdoorsiness”. The Raschplatz showed an inverted pattern: 70% considered it being outdoors, while the remaining votes were given to the other choices with number decreasing as the degree of “indoorsiness” grew. In case of the Passarelle, the most frequently selected category (neither indoors nor outdoors) received only a few more votes than the other categories. For the Posttunnel, many people tended to either classify it as indoors or outdoors and fewer people chose an intermediate value. While participants thus did not unanimously put the three transitional sites into one category, the overall distribution of votes differed considerably from site to site.

Route choice (in the direction-giving task) also varied – there was no predominantly chosen route. For example, the most direct route from location B to destination A is an almost straight line. However, we identified four alternative routes including some that required the traversal of several height levels as well as some routes that included the Posttunnel and thus constituted a considerable detour. All routes described by participants did include indoor, outdoor, and transitional segments (cf. Figure 3 (a) & (c)).

Overall, the results of our empirical study highlight the need to further deepen our understanding of transitional zones and also confirm that urban routes can be quite complex. In the following section, we therefore take a closer look at the route directions participants gave.

7 Linguistic Analysis

In order to validate the classification given by participants on whether they thought a given space was indoor, outdoor, or transitional, we followed an approach proposed by Landau and Jackendoff (1993) [17]. They analyzed how objects and places can be represented with language specifically based on count nouns and spatial expressions. The authors presented a list of linguistic expressions, which they considered important in understanding spatial relations expressed in words. In their study, they discussed comprehensively those linguistic expressions through the asymmetry between figure and reference objects as well as analysis in terms of the geometric aspects. The authors recommended an approach to assess the extent of different spatial relations by counting the frequency of the linguistic expressions used. We hence applied a similar approach in our attempt to explore how people refer to different types of spaces based on the spatial expressions mentioned. However, extensive linguistic analysis of the route instructions produced by participants is beyond the scope of this paper.

Our hypothesis was that different usage of linguistic expressions supports the claim that people distinguish the three types of space in their daily practices. These linguistic expressions are adjectives and adverbs that were used to describe wayfinding instructions with respect to the spaces – including the central station, Passarelle, Posttunnel, and Raschplatz. Therefore, the expressions serve

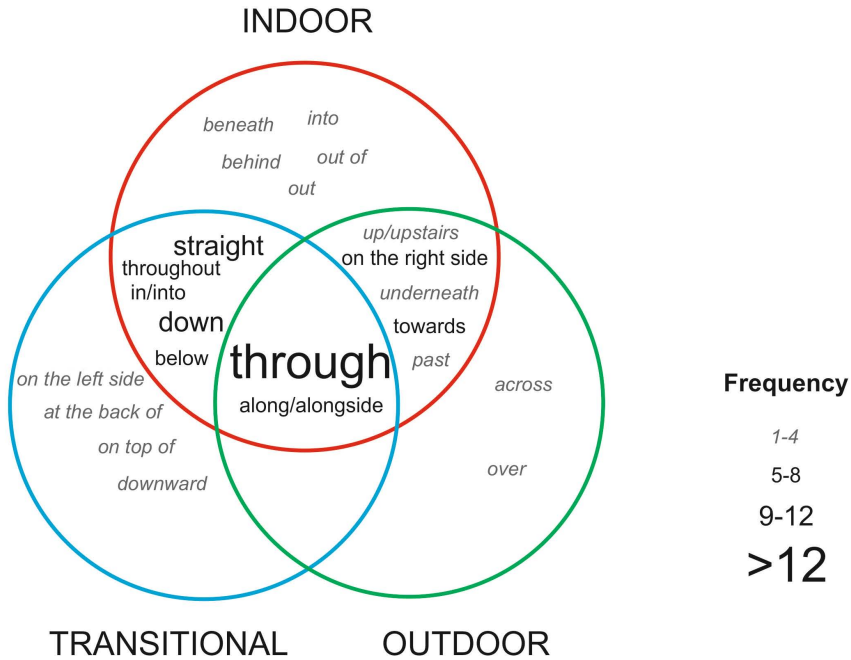


Fig. 4. Spatial expressions relating to indoor, outdoor, and transitional spaces; font size indicates overall frequency of usage (lowest frequency in italics for readability)

as determiners of how spaces could be classified as indoor, outdoor or transitional space. To carry out our linguistic analysis, we used a tool called AntConc [1]. Firstly, in our empirical study we paid particular attention to the spaces (differentiated in the theoretical analysis) that participants indicated in their wayfinding instructions and to the associated linguistic expressions, which they used to refer to these spaces. Secondly, the different spaces and their equivalent names were selected in the tool; phrases containing a selected spatial object and its associated linguistic expressions were then filtered. Thirdly, all linguistic expressions linked to the three different spaces were then counted and summarized. Table 3 gives a complete list of German terms and their English translations. Finally, based on the classification of spaces by participants, we examined if any two or all spaces share similar uses of linguistic expressions. Fig. 4 visualizes the usage of spatial expressions with respect to the different types of spaces and their overall frequency.

The linguistic analysis shows that some expressions are exclusively used with indoor spaces, while others only appear with outdoor spaces or transitional spaces. Some expressions are used to refer to two types of spaces indoor/transitional or indoor/outdoor. We find no expressions that are solely shared by transitional and outdoor space, but only a few which are commonly used to refer to all three types of spaces.

Table 3. Spatial expressions and their frequency of use for the different types of spaces

spatial expressions		types of spaces			total count
English	German	indoor	outdoor	transitional	count
through	durch	79	5	14	98
down	runter	6	-	4	10
straight	geradeaus	8	-	1	9
along, alongside	entlang	5	-	3	8
below	unten	4	-	3	7
towards	zum	5	2	-	7
in, into	in	2	-	4	6
on the right side	rechts	3	3	-	6
through	hindurch	3	-	2	5
underneath	unter	3	-	1	4
up, upstairs	hoch	2	2	-	4
over	über	-	3	-	3
on the left side	links	-	-	2	2
past	vorbei	1	1	-	2
across	drüber	-	1	-	1
at the back of	hinten	-	-	1	1
behind	hinter	1	-	-	1
beneath	drunter	1	-	-	1
downwards	hinunter	-	-	1	1
into	hinein	1	-	-	1
on top of	oben auf	-	-	1	1
out	aus	1	-	-	1
out of	heraus	1	-	-	1
sum		126	17	37	180

Two expressions are used with all three types of space. The participants use ‘through’ 98 times in the wayfinding instructions; ‘through’ is thus by far the most commonly used preposition. It refers to all three types of spaces, but it is predominantly used for indoor space. ‘Along or alongside’ is the only other linguistic expression used to refer to all three spaces. Considering both types and frequency of all expressions, most spatial expressions (70.0%) are used with indoor space, 9.4% are used with outdoor space and 20.6% are used with transitional space. Indoor space also shows the largest variability of spatial expressions used: 17 different expressions out of 23 expressions in total are used to refer to indoor space. Seven different expressions are used with outdoor space and 12 different expressions are used with transitional space.

Considering only the types of expressions, there are a few that are used exclusively within only one type of space: within all types of expressions that are used for indoor areas, 29% are exclusively used for indoor space, 22.2% of outdoor expressions are used exclusively for outdoor space, and 36.4% of transitional expressions are used exclusively for transitional space.

The data analysis revealed that most of the expressions used to describe transitional space are also used in describing indoor space. ‘Straight’ was predominantly

used with indoor space (89%) while 'down', 'below', 'in/into', and 'throughout' were almost equally used with both spaces. The four expressions 'to the left side', 'at the back of', 'down' and 'on top of' were used exclusively for transitional spaces. Outdoor space and transitional space do not exclusively share any spatial expressions. Five expressions are used for referring to outdoor and indoor space: 'past', 'to-wards', 'underneath', 'on the right side', and 'up/upstairs'.

8 Discussion

In this section, we review implications of our findings and discuss limitations our study were subjected to, based on the factual outcomes of the analyses we carried out.

The empirical survey partially confirmed the outcomes of our theoretical analysis, and provided initial evidence that our working definition of transitional spaces might be useful. The participants classified the Raschplatz as being clearly outdoors, which is what we were expecting based on the theoretical analysis. The same can be said about the Passarelle. In the cases of the Posttunnel and the central station, we observed more complex patterns. The participants tended to classify the Posttunnel as either indoors or outdoors but rarely as neither one nor the other despite the fact that the theoretical analysis had identified many similarities with the Passarelle. The central station resulted in the biggest disagreement of theory and practice. Formally classified as transitional space the participants mainly regarded it as an indoor space. However, with the exception of the Raschplatz, people did not produce a consistent classification for the presented spaces. This failure to clearly classify a space can be conceived of as an indicator of transitional spaces while the actual classification patterns of different transitional spaces may vary considerably.

Both the site analysis and the survey study were subject to a number of limitations. The categories we used emerged during the investigation of inner city spaces in Northern Germany. It is possible that further relevant categories exist, and that the set of categories might vary according to country or cultural sphere. The survey study involved more than a hundred participants but they did not constitute a representative selection of the population. Our results are thus not as general as they could have been. In addition, cultural differences are also not accounted for due to the study being carried out in a single city. Finally, we chose to write down the directions we requested from participants rather than to record them. This was done to not intimidate potential participants and to increase the number of participants but at the same time, this practice introduced an additional error source. Obviously, this also constitutes a limitation with respect to the linguistic analysis. In addition, the body of directions used for the study was small (slightly more than a hundred sets of directions).

From the linguistic analysis we can draw a number of conclusions. The data shows that the frequency and the variability of expressions used with indoor space was highest. This might be due to the spatial complexity of indoor spaces, which require complex wayfinding instructions to describe the different interaction possibilities. All three spaces have expressions that are uniquely used

with one space. This provides evidence that three spaces can be distinguished and are conceptualized differently. However, they also all share expressions used with other spaces. This is the case for transitional space as well, which supports our claim that there exists a transitional space in between indoor and outdoor space. With respect to overlapping expressions, transitional space shows more similarity with indoor space. One possible explanation for this observation could be a similarity in terms of complexity: transitional space is similarly complex as indoor space, often limiting movement and visual access.

The study demonstrated differences of spaces based on how participants used expressions in giving route instructions. While we cannot use the expressions to infer whether the place it refers to is in indoor, outdoor, or transitional space, but the usage and frequency of expressions provides evidence for the existence of differences between these spaces. The use of spatial expressions may also depend on the physical characteristics of the place wherein one expression may describe various spaces. Expressions such as ‘down’, ‘downwards’, ‘under’, ‘beneath’, ‘throughout’ or ‘below’ indicate a three-dimensional structure of the environment. Different levels predominately exist in indoor and transitional spaces, and to a lesser degree in outdoor spaces.

A further limitation of our study was that we only used four places to classify indoor, outdoor or transitional space. Due to the small number of places, we were not able to thoroughly investigate factors such as the physical characteristics. Consequently, a logical next step for further research would be to considerably expand the number of places given to participants in a follow-up study. In addition, three of the spaces under investigation were connected to each other (Passarelle, central station, Raschplatz). While this is not necessarily a typical pattern for transitional spaces in urban areas – further studies are needed to establish such patterns – it might potentially have affected the judgement of participants (though the Raschplatz was classified very differently from the other two spaces that were connected).

Summarizing the outcomes of our studies, we can thus observe that there are spaces, which people cannot clearly classify as being either indoors or outdoors. The spaces differ in terms of their properties and in terms of how people describe routes traversing them. Three of the sites we looked at matched our working definition of transitional spaces and exhibited properties we considered indicative of such areas. Given the well-documented differences between indoor and outdoor spaces, our findings have implications for urban navigation and provide a good starting point for future research. Systems providing personalized navigation support, for example, might have to adjust what directions they give (and how) when supporting users navigating transitional zones. While our study was not sufficiently extensive to fully define and investigate transitional zones, it can nevertheless serve as a starting point for future research into those spaces.

9 Conclusion

Previous work commonly only distinguishes between indoor and outdoor space. In this paper, we reported on initial evidence demonstrating that two types of

spaces are not enough: there is a third type of space – transitional space – that is neither consistently classified as being indoors nor consistently classified as being outdoors, and it shares properties with both indoor and outdoor space. We theoretically analyzed four example sites from an urban area, and found that three of them can be considered to be transitional spaces. An empirical study, involving 103 participants, largely confirmed the outcomes of the theoretical analysis but also brought to light that classification patterns for transitional spaces may vary considerably but they all share the property that no single category is vastly preferred. In a linguistic analysis, we examined wayfinding instructions given by participants, and the results showed that the types of spatial expressions as well as their variability differ among different types of spaces. Some spatial expressions were solely used for transitional space, whereas only some were used for two or all three spaces. Linguistically, transitional spaces showed more similarity with indoor space than with outdoor space. All three analyses thus provided initial evidence for the existence of transitional spaces as a third type in addition to indoor and outdoor spaces.

While this paper presented first theoretical, empirical and linguistic evidence for the existence of a new type of space besides indoor and outdoor space, further research in this area is clearly needed. In addition to studies on a larger scale and in different cities/countries, a detailed geospatial analysis of transitional spaces would be beneficial. The former would not only verify the findings of this paper but also expand the catalog of properties and help to identify the impact of cultural aspects. The latter may also result in specific spatial configurations that enable us to identify transitional spaces more easily. Both lines of research would also benefit the deeper understanding of the classification patterns we observed, and might help to identify further ones. Finally, the issue of how people navigate transitional space and how technology can support them in this task, is another promising area for further research that also is of high practical relevance.

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