Movement Navigator: A Relational Syntax Study on Movement and Space at King's Cross and Piccadilly Circus Underground Stations, London, UK

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Abstract

The article explores the design and analytical method Relational Syntax [1], using both a syntactical approach as well as on-site observations. The architecture of King's Cross and Piccadilly Circus Underground stations in London is used as the laboratory in which a theoretical discussion on movement and dimensional relations in architectural space is conducted. The two stations are among the most well-known and used in the London Underground system. Observations were made at these highly-used stations in order to establish an overall understanding of the spatial mechanism through social and natural movement. Considering the case studies as both texts and experiences, the article shows that spatial analysis and bodily movement can be explained, compared and put into sets of relations that can be pre-established or scripted during architects' design activities. It is argued that the concept of 'script' [2] can be used bi-directionally in both the design and analysis of architecture. The research and arguments presented in this paper are being developed to form the basis of an application tool. Based on the theory of Relational Syntax, this application tool can be used to process building requirements generated from the design or analysis of a piece of architecture into scripts in order to systematically and aesthetically describe and generate spatial relations in buildings.

Keywords

Relations
Syntax Space
Design
Movement
Station

Introduction

When observations at King's Cross and Piccadilly Circus Underground Stations began, the project was full of questions: Are stations buildings or places? Are they architectural space or spatial architecture? What does it take to visualise the space of this kind? How are the spaces perceived and directed through their labyrinthine characters? Are cultural aspects one of the shaping tools of these spaces? How does body movement inscribe these specifically designed spaces for movement? These questions serve as targets to achieve in order to understand the architectural quality of space which is beyond physical descriptions in building plans, sections and elevations. This understanding of space will enable the architectural design process to generate spatial envelopes that are cohesive and responsive to use and movement.

The architecture of underground stations might be expected to have special characteristics in their forms and social events. Their presence is so subtle yet people experience them everyday. The boundaries appear to be dynamically defined by the pure need to achieve economics of effort in use and movement. They are places to go to as much as places to leave from. Their dialectic qualities are superimposed with the dynamism of events and the desire of people and machines to move beyond their static spatial representation of envelope.

The observations of these underground stations therefore focus on the impact of spatial configuration on body movement and vice versa. In these spaces no one is static, not even the homeless; it seems that everything and everyone in the space is moving around from everywhere to everywhere else. King's Cross Underground Station injects and collects various pedestrian movements to and from the London Underground system while Piccadilly Circus Underground Station is clearly one of the hubs or reference points for most of central London's pedestrian movement [3].

The idea of the body and its movement as a generative tool for built form and environment is an ancient idea that has existed in most cultures since we first learned to elaborate our representation technique. Even though humans give first priority to existence they somehow fail to systematically understand and clearly optimise the integration of body movement with the space it is in. Therefore, architects tend to usually *think 'of'* building elements and do not deal directly with space and its configurations. More often than not, whenever 'movement' issues are mentioned in architecture the emphasis is on designing 'the backdrop' for any unspecified movement or the 'sculptural' quality of architectural elements that appear to 'move'.

Despite many examples of good design which show high quality of dynamism in architecture, it is more objective to consider space which is not 'privately commissioned' for particular individuals. By considering the space in which public activities take place, a general understanding of people movement and how it influences the architecture of space can move towards a focus on natural movement. The space of underground stations is such a space that exists to efficiently facilitate all kinds of natural movement to and from them. With such dynamic and intense movement, it is very interesting to investigate whether the space that is currently in use is the result of conscious design that was conceived well in advance by designers or whether the space (including non-architectural elements such as engineering requirements) must constantly change and is the result of natural movement.

The architecture of underground stations offers a new unfamiliar type of built environment. It is relatively new in function, in need, in use, and in spatial form. This could also mean that it is new in concept, in society, in application, and in built form. Though stations may become homes (for the homeless), offices for workers or indeed stages, for buskers, stations are not immediately recognisable as any of these. Are stations specific building types or are they places that have resulted from random movement? Different usages mean that no clear definition can easily be applied to stations because what one first encounters when entering stations is not only architectural features but also spaces originating from engineering advances and new kinds of usage and movement.

Several contradictions are enunciated through station spaces, the first of these is the lack of historical reference and yet the importance of time to station users. Though at the time the stations were designed, the architects could not predict with any certainty the usages that their new spaces would be put to, the spaces that emerged were architectural in the same way as houses have conventional architectural features. They were designed and built with few historical references in terms of space usage. Though historical time was not a central issue during the design process, time has always been a central element in the usage of stations, all stations have clocks, people who use stations look at watches, clocks, mobile phones and other time pieces, to gauge the amount of time left to reach their destination in good time. In this way, the architecture is associated with timelessness because there are so many timeframes intertwined in its space. When time is disregard as a whole movement becomes more independent from space. In such a place envelopes/architecture is mold more by movement than by other factors.

The first priority for users is the desire to move from here to there and vice versa, it is a practical desire, with little reference to easily recognisable cultural or social aspects. This would appear to be a result of the fact that when designed, there were few architectural precedents to accommodate this new type of movement and usage, consequently there was no reference for using the newly created space for socio-cultural activities.

A second apparent contradiction which also highlights the efficiency and mechanicalism of stations is the fact that though station users are a highly diverse group of people, usage of station space has little diversity, people use the space to facilitate their travel and movement. The architectural properties of the space, force movement convention onto proudly different users. This type of space exists to deal with movement, not perception of architectural aesthetic. One only needs to follow the crowd (and some signage) to get where one wants to go.

This project, consisting of on-site observations carried out in 1996, tries to analyse and visualise how body movement influences the emergence of space, in this case, of one of the most widely-used built environments: train stations. Graphics depicting movement volume or types will be used to show movement directions, positions, sequences, rhythms and configurations. Photographs from actual locations will be used to compare, clarify and relate on-site situations to diagrams and drawings. The use of Relational Syntax methodology and the concept of script is an experiment that is intended to be a generative tool for design activity. It is hoped that through a system relating various factors of movement and space more efficient design activities will be promoted and therefore, better design possibilities

will be generated. Furthermore, the consideration of train station spaces, which emphasise space rather than architectural precedence, will allow a more direct investigation into the relationship between movement and space. The understanding gained will serve as a platform for further Relational Syntax study on space and movement in other built environments.

Design for Dynamics

It is well known that the architects of London Underground stations were inspired by the developments of the age of machine as well as the theory of "Functionalism". "*...the beauty of the building was a product of the efficiency of the design. The prime considerations were the most efficient utilization of internal space and freedom of movement. Scale and proportion, and the arrangement of forms come to the fore; cubic and cylindrical shapes - the basic classical forms - with clean planes and sweeping curves, were adopted by the movement as expressions of the 'machine' aesthetic* [4]." This concept had a great impact on many of the architects of the 1930s and certainly on the architects assigned by the Underground Group to modernize London underground stations. King's Cross/St. Pancras Underground station (Figure 1), originally designed by Sir John Fowler and John Hargrave Stevens in 1863, was modernized with a new circular ticket hall in 1939 while Piccadilly Circus's renowned circular ticket hall (Figure 2) was completed in 1928 and designed by Charles Holden (Figure 3).

"*In the morning it is like a turbine grinding out human beings on all sides. In the evening it sucks them in again, through the circle and down the escalator to the rushing trains* [5];" the impression of Rasmussen on the circular design of Piccadilly Circus's ticket hall reflects the idea of machines and the movement they generate. King's Cross adopts the same strategy. Initially introduced

Figure 1 King's Cross/St. Pancras Station Underground station

Figure 2 Ticket Hall at Piccadilly Circus

Figure 3 Charles Holden

into the design of Piccadilly Circus's ticket hall by Holden, circular ticket halls at both stations are overcrowded during peak time and they are both ranked in the top five busiest London Underground stations.

There are six stations between King's Cross and Piccadilly Circus and a journey between the two will take about 10 minutes on a Piccadilly Line train and about forty five minutes on foot through the city (Figure 4). In terms of ticket sales, King's Cross was at fourth place and Piccadilly Circus was in eleventh place in 1994/95, with annual entry/exit at 43.8 and 35.2 million usages in 1996 at King's Cross and at Piccadilly Circus respectively [6]. Movement is circulated through the ticket halls, and through linkages such as escalators, stairs and subways; there are no lifts or ramps for public usage.

Figure 4 Locations of the stations in the city and on the London Underground map (King's Cross and Piccadilly Circus Underground stations highlighted)

Comparisons of how the stations are used reveal that while both are important within the city, they fulfill different movement functions. King's Cross station is highly utilized as an interchange, it has the second highest number of interchange usages in the London Underground system (22.4 million excluding other over-ground train interchanges) [6]. The geometry of the station seems to be determined by the movement around it; these movements come from all directions on ground level and 'penetrate' underground to the trains via the station's nine access points (Figure 5). There are four spines of platforms for six underground lines: Piccadilly, Northern, Victoria with Circle, Metropolitan and Hammersmith & City Lines sharing one spine of platforms. At King's Cross station, the powerful circular geometry of the ticket hall draws the movement above ground downwards while underground movement is distributed through an efficient and extensive network of linkages.

At Piccadilly Circus station, there are only two spines of platforms serving the Piccadilly and Bakerloo Lines. The station was not in the top ten interchange usage ranking however it was ranked in fifth place in annual entry/exit ranking in 1996. These statistics show that at King's Cross station movement is much more internal than the movement in Piccadilly Circus station. It is interesting to note that observations about usage, city location and usage statistics suggest that though both stations have similar circular ticket halls, the stations generate movement effects of different kinds. At King's Cross movement appears to be heavily 'drawn' down into the station. In contrast, at Piccadilly Circus station movement appears to be 'spun' off from below. It is considered that these differing movement effects are strongly linked to city location. Movement at Piccadilly Circus must circulate at a faster rate and effectively integrate above ground city space with underground space, the station's function is related to the character of

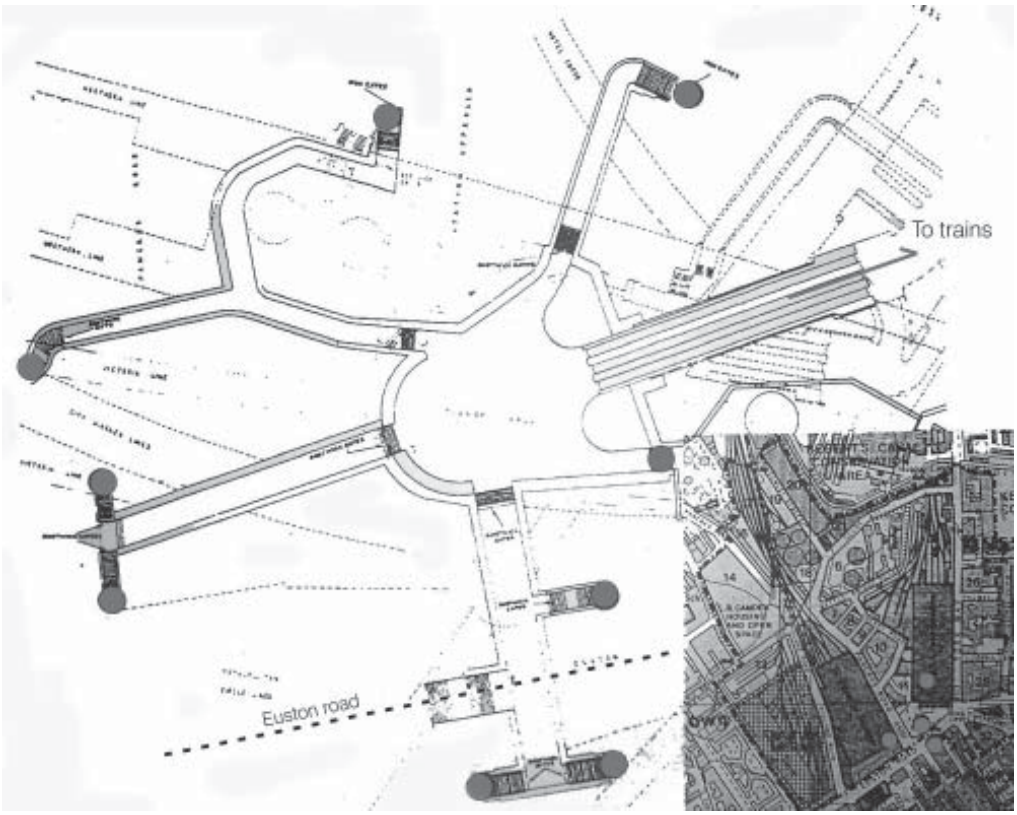


Figure 5 Access points at King's Cross Underground station (LUL 1996)

Piccadilly Circus being a 'crossroads' in the city. There are seven exit points that are strategically placed to efficiently release movement to the ground level and into the city fabric. (Figure 6)

In both stations, people move through space in the most economical ways and the experience of moving through space takes the form of linear sequences with fixed frame references. People are always directed through space either by signs or they simply go with the flow suggested by the geometry of the spatial containers. The observations were conducted so that the relations between the types of Experiential dimension (passage, junction and place) [7], volumes of movement and architectural elements [8] can be discussed. Frequencies of movement based on observations will be used to further discuss the relations between design strategies, spatial configurations and structure of movement in the stations.

The observations were made at the splits/ junctions to different train services from the ticket halls (King's Cross) or at the points where the ticket halls and the subways meet (Piccadilly Circus). (Figures 7A&B.) The analysis focuses on the relationship between the ticket halls and the many underground spines; major spaces that form the architecture of the stations. The observations at King's Cross focused on movement going into the station while at Piccadilly Circus the observations focused on movement going out of the station. The two stations provide examples of how to design space that efficiently releases and receives movement, enabling the method of design to be studied.

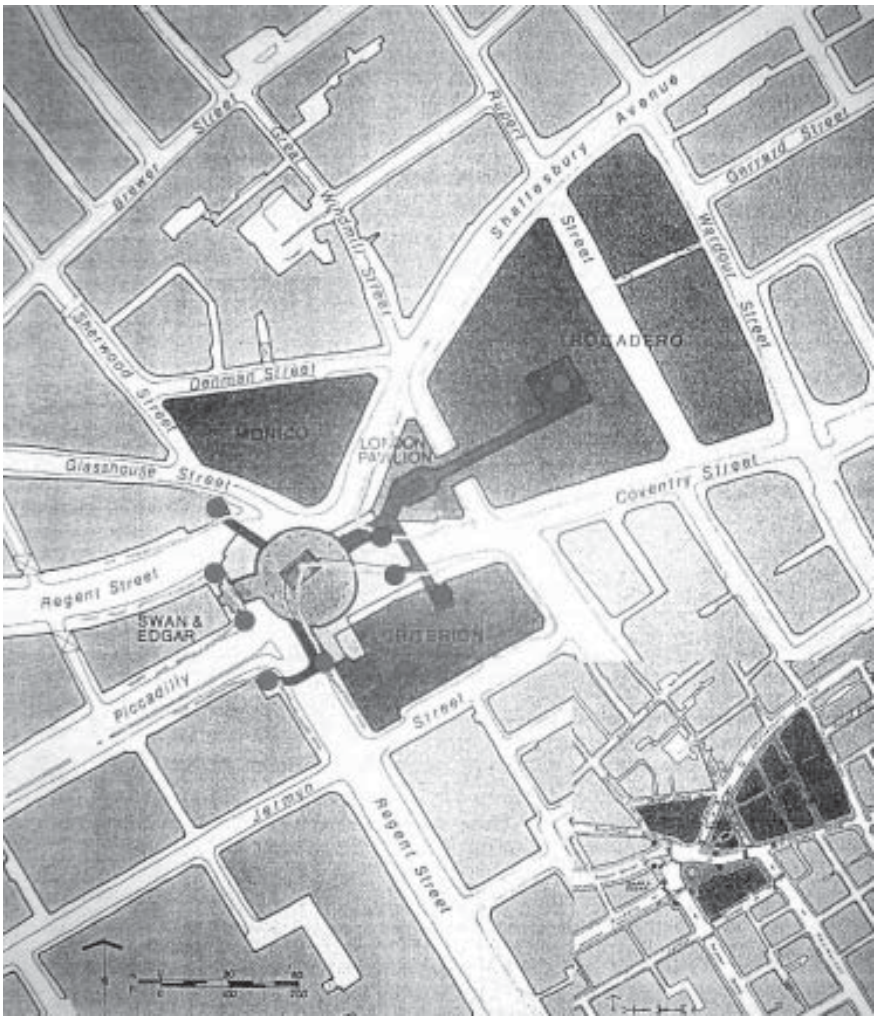


Figure 6 Access points at Piccadilly Circus Underground station (LUL 1996)

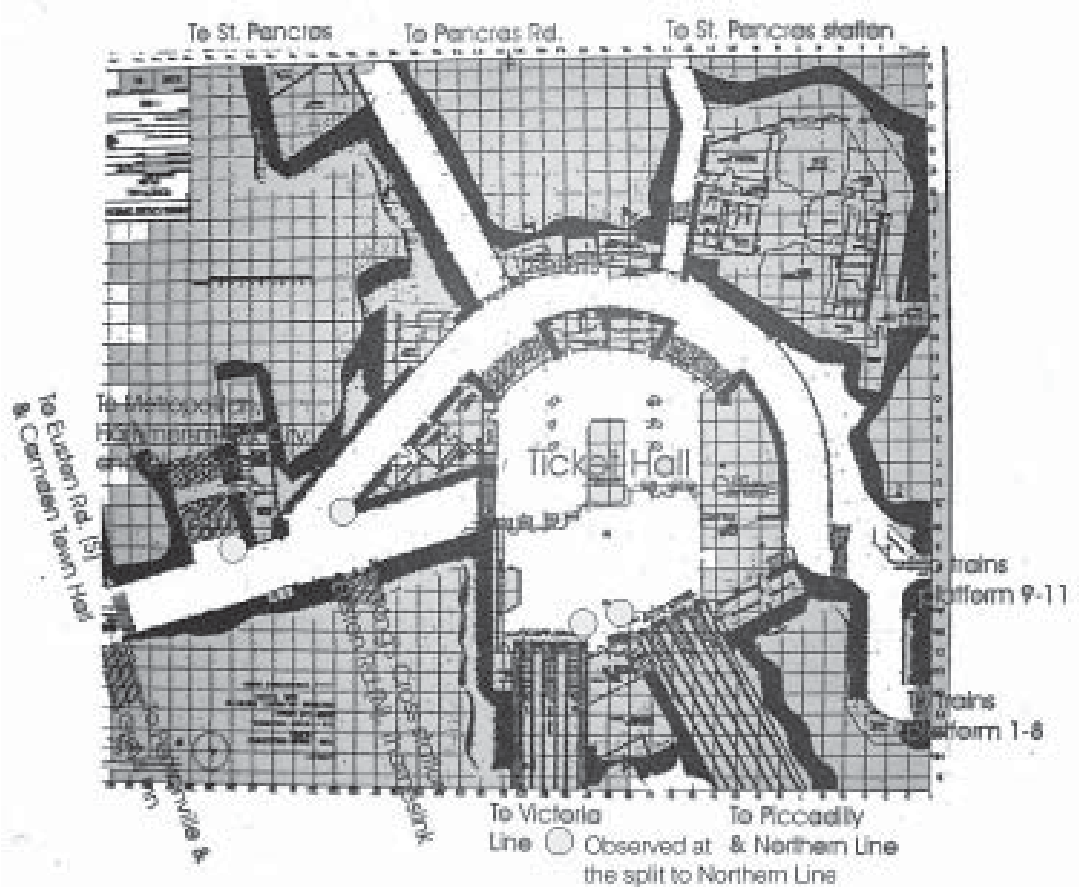


Figure 7A Observation Locations at King's Cross Underground station, plan at ticket hall level (LUL 1996)

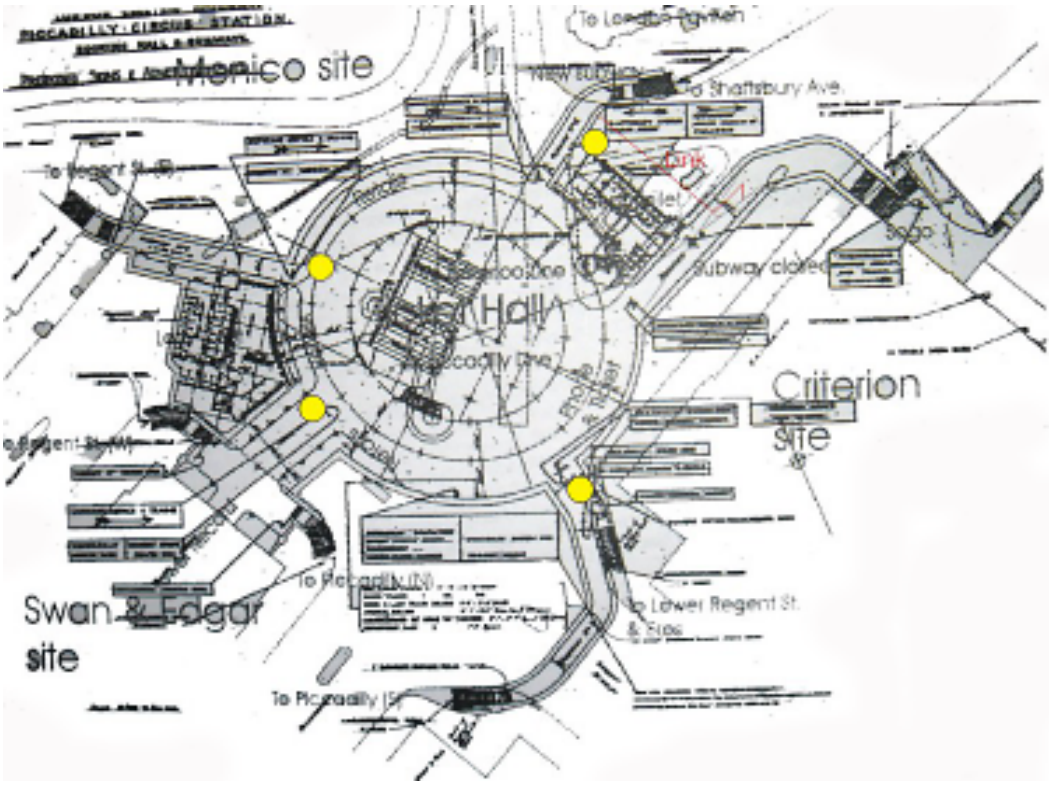


Figure 7B Observation locations at Piccadilly Circus Underground station, plan at ticket hall level (LUL 1996)

The observations at both stations focused on ticket halls and subway spines. The same method was used to observe movement in the ticket halls and subway spines of both stations. King's Cross station space is twice as large as that of Piccadilly Circus and seems to contain many more kinds of movement and thus feel bigger and more 'dynamic' than Piccadilly Circus's. There are fewer constraints on the site, fewer functions in the ticket hall and fewer types of activities taking place in King's Cross space however it is similarly overcrowded. King's Cross Underground station is very complex in many aspects; it is described as "*...the only 'four-tier' station on the Underground system. The whole of the work here, including line and station construction and equipping, took roughly 3 □ years. ...The Victoria Line is above the other tube lines but below the Metropolitan* [10]."

The configuration of King's Cross space was moulded by many requirements, mostly non 'architectural' one as Glover wrote "*At the ticket hall level, the Fleet sewer had to be diverted and recontained in a new concrete ring and box construction, which at one point nearly obtrudes into the ticket hall. ...without any visual means of pinpointing obstructions as would be the case above ground* [10]." These unpredictable elements played a vital role in the emergence of the architecture of underground stations. Other requirements such as safety and mechanical aspects also greatly contributed to the architectural and spatial forms of the stations [11]. King's Cross Underground station has amazing forms and circulation systems which are partly the result of the considerations and necessities mentioned in the quotation above (Figure 8). Movement, however, is the most important element in the existence of underground stations.

People enter from one of King's Cross station's four spines which draws movement to the main ticket hall. The ticket hall and the four spines are known to resemble a palm with five fingers (one spine connects with St. Pancras railway station). The 'index' and the 'middle' fingers are the

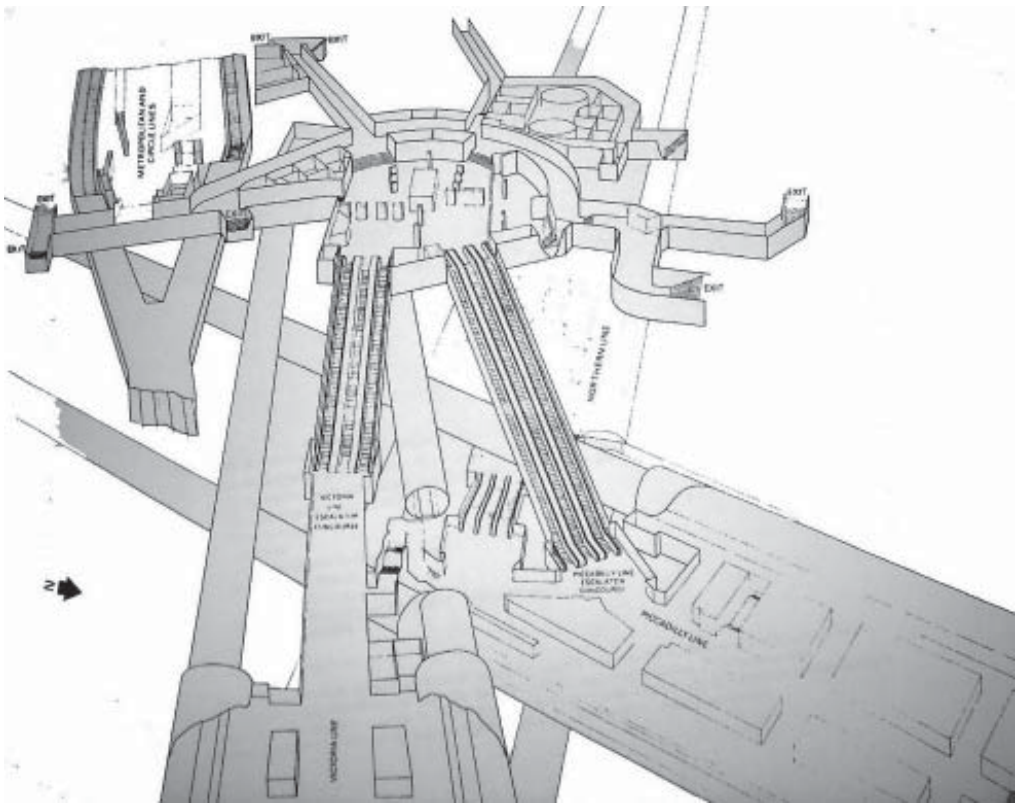


Figure 8 Architecture of Ticket hall at King's Cross Underground station (LUL 1996)

escalators linking down to Piccadilly, Northern, and Victoria Lines. The observations took place at the ticket hall level and a count was made at the points where movement splits down the 'fingers' to all five Underground Lines. Tables 1 and 2 show the amount of movement in the space of King's Cross Underground station during weekdays and weekends, respectively. Comparatively, the ticket halls and subway spines at King's Cross station are slightly larger than those at Piccadilly Circus. However, King's Cross also has many more interchange activities than Piccadilly Circus and thus serves a bigger volume of movement.

In contrast to Piccadilly Circus, there is no one peak period at King's Cross. During weekdays the station seems to be busy throughout the day and statistics show that the largest volume of movement changes to different parts of the station during the course of the day (Table 1). Of all the spines, the one that leads to the Northern Line service accommodates the highest number of people during the weekdays about 120,000 people per day (note that the Northern Line service is the deepest from the ground level - 27.00 metres). At weekends, the most crowded spine is the one linking the ticket hall to the Circle, District,

King's Cross Underground Station: weekdays

Point of observations	Periods of observations (5 mins count/ period)	Moving Men	Moving Women	Moving Teenager	Moving Children	Total
Piccadilly Line	08.00 - 10.00	**145**	99	13	1	**258**
	12.00 - 14.00	77	46	21	3	147
	16.00 - 18.00	57	38	24	1	120
	20.00 - 22.00	67	35	12	-	114
Northern Line	08.00 - 10.00	82	67	14	2	165
	12.00 - 14.00	**159**	65	21	1	**246**
	16.00 - 18.00	114	95	10	3	222
	20.00 - 22.00	51	59	6	4	120
Victoria Line	08.00 - 10.00	**90**	60	8	5	**163**
	12.00 - 14.00	71	69	14	3	157
	16.00 - 18.00	51	54	12	3	120
	20.00 - 22.00	59	37	5	-	101
Circle,	08.00 - 10.00	121	72	11	2	206
Metropolitan and	12.00 - 14.00	70	93	9	3	175
Hammersmith &	16.00 - 18.00	**253**	163	16	6	**438**
City Lines	20.00 - 22.00	97	91	14	1	203
Total	80 minutes	**1564**	1143	210	38	2955

Table 1: Observations at King's Cross Underground Station: Weekdays

Metropolitan and Hammersmith & City Lines service (93,000 people per day, also note that this service platform is at the shallowest level - 7.00 metres). At weekends, the station seems to be busiest during lunchtimes (12.00-14.00) when there are about 7,600 people moving about in the station per hour.

The volume of movement observed at King's Cross station on an average day (at least 470,000 people per day during weekdays and at least 300,000 people per day at weekends) corresponds to London Underground's survey of entry/exit numbers at both stations (43.8 million of King's Cross versus 35.2 million of Piccadilly Circus). However, observations show that King's Cross seems to deal with a constant stream of movement while Piccadilly Circus has to cope with sharp surges of movement. Furthermore, the statistics show that Piccadilly Circus is much busier during weekends than on weekdays. In contrast, despite constant high demand, King's Cross is busier during weekdays than it is on weekends.

For example, comparing the volume of movement during the same rush-hour period (16.00-18.00), at Piccadilly Circus, there are about 6,000-8,000 people/hour on weekdays and weekends,

King's Cross Underground Station: weekend

Point of observations	Periods of observations (5 mins count/ period)	Moving Men	Moving Women	Moving Teenager	Moving Children	Total
Piccadilly Line	08.00 - 10.00	47	24	11	4	86
	12.00 - 14.00	**87**	63	13	3	**166**
	16.00 - 18.00	46	29	34	5	114
	20.00 - 22.00	75	19	26	5	125
Northern Line	08.00 - 10.00	28	16	21	6	71
	12.00 - 14.00	**85**	44	17	-	**146**
	16.00 - 18.00	32	28	6	2	68
	20.00 - 22.00	46	16	24	5	91
Victoria Line	08.00 - 10.00	32	34	4	4	74
	12.00 - 14.00	48	40	16	2	106
	16.00 - 18.00	**96**	68	16	6	**186**
	20.00 - 22.00	32	9	10	2	53
Circle,	08.00 - 10.00	49	55	13	7	124
Metropolitan and	12.00 - 14.00	**101**	76	27	11	**215**
Hammersmith &	16.00 - 18.00	55	84	19	2	160
City Lines	20.00 - 22.00	53	25	17	2	97
Total	80 minutes	**912**	630	274	66	1882

Table 2: Observations at King's Cross Underground Station: Weekend

respectively. At King's Cross, there are about 12,000 people/hour on weekdays but only 7,000 people/ hour on weekends. At this stage, it is possible to suggest that Piccadilly Circus station is a 'weekend' station and King's Cross station is a 'weekday' station. Personal usage of the two stations during a five years period (1996-2001) suggests that both station spaces generally work very well on most occasions.

People are grouped into four types: Men, Women, Teenagers and Children as these represent common types using London Underground. Tables 1 and 3 show usage rates during weekdays and tables 2 and 4 show weekend rates.

At the level of Piccadilly Circus ticket hall level, there are four subways providing access to the basements of many important overground places around the Circus [9]. The following tables show the frequency of movement of people in and out of the four subways. The observations were conducted at the entry/exit points of each subway during peak periods namely: morning rush hour (8.00-10.00), lunch time (12.00-14.00), evening rush hour (16.00-18.00) and after work/dinner periods (20.00-22.00). The weekend observations made at Piccadilly Circus Underground station were done outside of peak hours, for example the morning rush hour due to the late opening hours of businesses in the Piccadilly Circus area during weekends.

The space of Piccadilly Circus ticket hall is often packed full during peak hours on a Saturday evening. The flexible circular design means that it is effective in dealing with circulation of a large crowd. The well integrated subways and exit points help create flows around the perimeter of the ticket hall. With a variety of services and retail shops lining the perimeter of the ticket hall, the station enjoys the sense of being an urban plaza, as the word 'circus' suggests. The geometry of the 'circus' space interacts with movement at 360 degrees and closely relates three levels: ground, subsurface and underground (Figure 9).

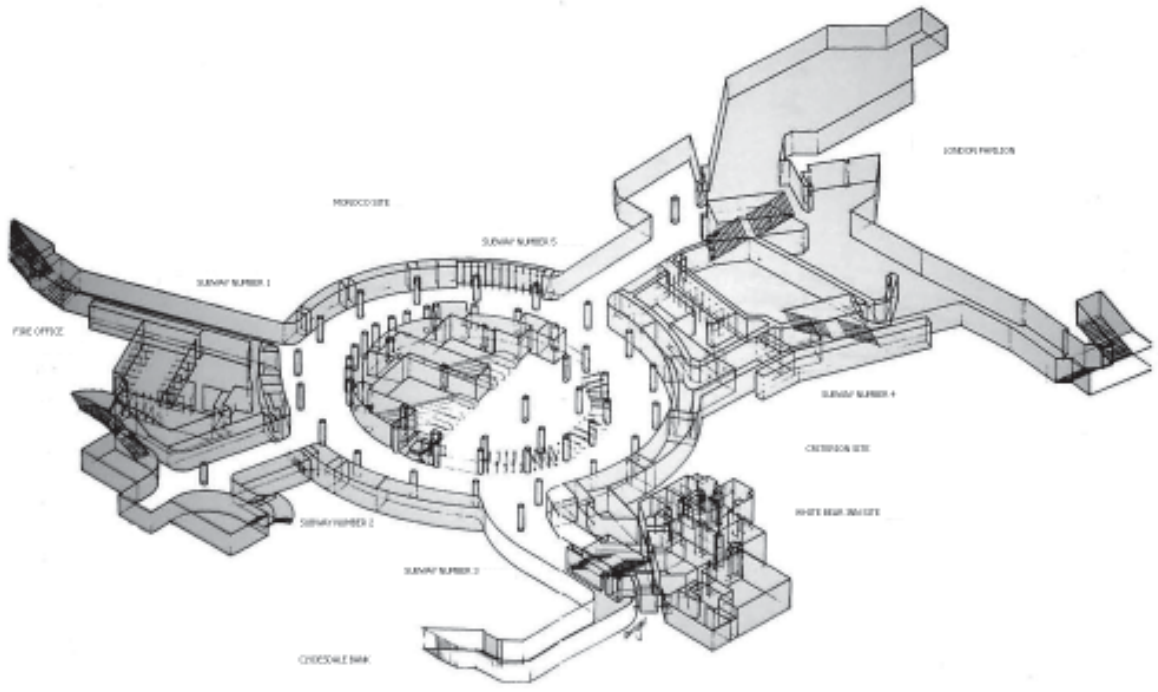


Figure 9 Architecture of Ticket hall at Piccadilly Circus Underground station (LUL 1996)

One can see from Tables 3 and 4 that the busiest period at Piccadilly Circus Underground station is between 16.00-18.00 on both weekdays and weekends. During this period, the station has to deal with at least about 6,000 people per hour on normal weekdays and at least 8,000 people per hour on weekends. This means that during a regular 13 hour-service day at this station at least 78,000-110,000 people move about in the station space during weekdays and weekends, respectively. There are 10 million registered Londoners but day time periods see the number of people in the city, commuters and tourists alike, almost double. Consequently the number of potential underground users is also multiplied.

Piccadilly Circus Underground Station: weekdays

Point of observations	Periods of observations (5 mins count/period)	Moving Men	Moving Women	Moving Teenager	Moving Children	Total
Subway 1:						
Regent (North&East):	08.00 - 10.00	20	39	15	1	75
Royal National Throat,	12.00 - 14.00	21	10	6	-	37
Nose, and Ear Hospital,	16.00 - 18.00	**39**	25	12	-	**76**
Lady Toilet	20.00 - 22.00	12	23	10	1	46
Subway 2:						
Piccadilly (South&West):	08.00 - 10.00	21	14	3	-	38
Museum of Mankind,	12.00 - 14.00	32	22	4	1	59
Royal Academy	16.00 - 18.00	**49**	24	14	3	**90**
(Burlington House)	20.00 - 22.00	36	19	18	-	73
Subway 3:						
Lower Regent (South side):	08.00 - 10.00	44	53	3	-	100
British Travel Centre,	12.00 - 14.00	53	62	2	-	**117**
London Library, Pall Mall,	16.00 - 18.00	**69**	26	18	-	113
St. James's Palace, Travel Information Centre	20.00 - 22.00	32	34	11	3	80
Subway 4:						
Shafsbury Ave.:	08.00 - 10.00	49	32	-	-	81
Haymarket and Eros, Sogo Dept. Store, London Pavilion, Gent Toilet,	12.00 - 14.00	60	24	4	1	89
Design Centre, OLT Sightseeing Tour, Swiss	16.00 - 18.00	**97**	48	25	3	**173**
Centre, Royal Dental Hospital, Trocadero & Sega World	20.00 - 22.00	78	47	36	3	164
Total	80 minutes	**712**	502	181	16	1411

Table 3: Observations at Piccadilly Circus Underground Station: Weekdays

From the numbers shown above and the locations of the two stations, King's Cross Underground station can be characterised as 'a place to go from' and a 'weekday space' while Piccadilly Circus Underground station is 'a place to get to' and a 'weekend space'. It is quite obvious that King's Cross station would draw movement because of the multiplicity of destinations available by a direct journey or by a single change.

Both stations have supporting facilities in the ticket halls. At King's Cross, facilities are more basic and fewer than at Piccadilly Circus. There is a great variety of shops and services along the perimeter of Piccadilly Circus's ticket hall (e.g.: one-day dry cleaning service shop, a shoe repair shop, a souvenir shop, a watch repair shop, a music & games megastore, newsagents, a travel information centre, money changing service, a grocery shop, a Ticket master, a film & camera shop and a

Piccadilly Circus Underground Station: weekend

Point of observations	Periods of observations (5 mins count/period)	Moving Men	Moving Women	Moving Teenager	Moving Children	Total
Subway 1:						
Regent (North&East):	08.00 - 10.00	-	-	-	-	-
Royal National Throat,	12.00 - 14.00	**30**	32	8	2	**72**
Nose, and Ear Hospital,	16.00 - 18.00	27	19	14	5	65
Lady Toilet	20.00 - 22.00	9	11	2	-	22
Subway 2:						
Piccadilly (South&West):	08.00 - 10.00	-	-	-	-	-
Museum of Mankind,	12.00 - 14.00	45	29	15	10	99
Royal Academy	16.00 - 18.00	**70**	39	16	12	**137**
(Burlington House)	20.00 - 22.00	14	3	-	-	17
Subway 3:						
Lower Regent (South side):	08.00 - 10.00	-	-	-	-	-
British Travel Centre,	12.00 - 14.00	37	25	7	6	75
London Library, Pall Mall,	16.00 - 18.00	**93**	71	25	6	**195**
St. James's Palace, Travel Information Centre	20.00 - 22.00	25	8	5	-	38
Subway 4:						
Shafsbury Ave.:	08.00 - 10.00	-	-	-	-	-
Haymarket and Eros, Sogo Dept. Store, London Pavilion, Gent Toilet,	12.00 - 14.00	90	59	39	24	212
Design Centre, OLT	16.00 - 18.00	**114**	54	69	7	**244**
Sightseeing Tour, Swiss Centre, Royal Dental Hospital, Trocadero & Sega World	20.00 - 22.00	53	22	37	2	114
Total	80 minutes	**607**	372	237	74	1290

Table 4: Observations at Piccadilly Circus Underground Station: Weekend

fast food stall). These facilities are placed close to the subways along the circular corridors of both stations. Locations like these encourage faster and easier interaction with movement and also send out '*the establishment of goodwill and good understanding between the passengers and the company* [12].' This idea can be found on a larger scale in New York City's Subway at 52nd St. station where subways integrate with a big underground shopping complex, the Rockefellor Centre. The situations at King's Cross station can be compared to that of 42nd St. station where a lot of interchange activities take place.

The ticket hall at King's Cross station circulates movement using its 'fingers' to radiate the flow of people at almost 360 degrees. A bypass route rings the perimeter of the ticket hall in order to join all the 'fingers' together. At Piccadilly Circus station, the dissipated movement in the centre of the ticket hall is directed by the uniform movement of escalators and subways. Such a rigid configuration of space in both architectural elements prepares people and their movement to be more mechanical-like. Specific geometric seems to provide for more economical movement in a similar way at both stations.

The continuous and uniform movement of space at escalators and subways can effectively absorb large volumes of movement with minimum congestion. Such geometry requires less space because people stand still on moving escalators therefore there is no natural rhythm in movement. The effect is reversed on the way up towards the ticket halls; natural rhythm of movement starts to be restored into bodies readied to spread into the open space of the ticket halls at the end of escalators or subways.

The statistics presented in this article are not the main point of discussion but serve to show how such spaces can provide some of the best examples when studying architecture and movement. Statistical information in this article is evidence of the growing influence of usage and movement in designing this type of building. At King's Cross, the space 'draws' people in and down to the underground as well as maintaining a large volume of interchange activities while at Piccadilly Circus, the station works very well in connecting people to the city at ground level since it does not serve as a main interchange station. As mentioned earlier, the station space seems to 'spin' people off of itself.

In terms of image and public recognition, both stations are on the same underground lines therefore, both being important stations, they seem to feed each other and have both become 'landmarks' in the London Underground system. The space in the ticket halls in both stations have similar geometry: the 'palm' and the 'oval' shapes. Therefore, it appears that movement is circulated by similar spatial strategies: gyration, peripheral distribution and tangential connections may be the most distinct effects which are in action in the spaces. Such strategies allow the important phenomenon of the emergence of individual paths and movement to 'branch off' from the main axes. 'Short cuts' are made in space; they coexist and, together with other design strategies, appear to be a movement navigator for people.

At this point, the overall effect of both stations has been established from observations. Further detailed explanation using Relational Syntax methodology will show how and why particular spaces in both stations perform certain architectural and spatial effects.

Movement Navigator

Charles Holden, the architect of many London Underground stations, once mentioned how the design of Sudbury Town station was arrived at "*The first stage was to prepare a graph of passengers' movement... The ultimate plan was produced by enclosing the graph by the walls*" [13]. The important thing is the development of a strategy that can clearly represent movement of three-dimension matter and also serve as a generative tool in design. As mentioned earlier, underground station case studies, where the architecture is heavily influenced by movement, allow in-depth discussion on design and movement in the built environment. Relations between architecture, movement and dynamism can be investigated through the analysis of the structure of movement and the influence of people movement on space and vice versa. This is a concept, an idea which architects may find useful to *'think with,'* a template of relations used during design.

The article will next proceed by firstly introducing the theoretical framework of Relational Syntax on which further discussion on King's Cross and Piccadilly Circus Underground stations will be based. The discussion will involve certain concepts and specific terms used in my ongoing architectural research and practice. This will be discussed first in general situations and concept before visualising it in case studies spaces. Due to the nature of architectural problems, ongoing research is being conducted through lab-based projects and professional design projects. Therefore the following argument lays the implication of theoretical information onto an existing built environment.

Together with Relational Syntax, the analysis proposes a 'plug-in' concept of *script* that uses movement as generative tools for the purpose of describing and prescribing spatial experiences and possibilities in the built environment. As Holden realised in 1944, architects can learn from movement in the same way as choreographers have been learning from it. However, "*The architect usually proceeds as artfully and subtly as possible to produce a place in which the institution-as-is can flourish* [14];" this situation mixes design creativity with artistic skills and architecture with buildings. Between the two qualities, architects should give priority and energy to design creativity and seek to generate something new.

Underground stations then, seem to be a good example of how looking at purely movement allows the architect to be able to focus on creativity rather than on the preformed, institutionalised concepts of space, which usually direct the form of houses or temples. Underground stations do not yet conjure up any preformed ideas as a building type to direct the architect leaving freedom to use creativity in a new way.

"*...it is difficult to assess whether we actually identify the will of the people correctly. At the moment, there are surprisingly few mechanisms in which the public's disapproval or approved can be made manifest to architects* [15]." To this point, it is suggested that architects can assess the fundamental needs of people in buildings through observations of their movement. Relational Syntax concept [16] and the idea of script hope to provide a tool that aids intuitive design activities using information from syntactical analysis and on-site observations. By doing so, architects can construct strategic sequences for spatial designs that are creatively responsive to actual needs and movement. Putting scripts together creates beautiful arts for choreographers, film directors and the like; it is proposed that the use of Relational

Syntax 'script' concepts would help architects to design spatial envelopes that emerge from the beauty of in-depth information.

There are three steps to extracting the information. Each step involves the analysis of the three main elements: Convex space, Experiential dimension and Relational Syntax.

1. Convex space

Space Syntax theory is used as the reference when identifying configurations of space in buildings [17]. Space Syntax quantifies space using Convex space which is a topological form of space defined by topographical characters in buildings. To be able to identify the Convex spaces of a building, one has to understand the social usages of space in the building (on-site experience is needed). For example, drawings of Convex spaces for King's Cross (Figure 10) and Piccadilly Circus Underground stations (Figure 11) can be made after the on-site observations as follow:

In addition to the functional information in building plans, to draw Convex spaces one has to understand the way people use and move in those buildings. Usages and movement in the space of King's Cross and Piccadilly Circus stations are therefore seen as design elements which fundamentally comprise a central gyrating space (ticket hall) and a series of uniform spines (subways). The connections between Convex spaces (the dashes between two boxes) represent accessibility on foot and as a whole represents the way buildings are structured from series of spaces. As seen in graphs, convex space works in four ways in a spatial configuration: a-type, b-type, c-type and d-type spaces [17] (Figures 14 A-B). This is the concept of Structural dimension in Relational Syntax.

2. The Experiential dimension

The Experiential dimension of a building or space is obtained through on-site observations. An observer must 'participate' in the social activities taking place in the building by moving about in it in order to understand the Experiential dimension. Fundamentally, there are three types of movement experience: passage, junction and place [7].

Passage: Space in corridors, walkways, staircases, escalators, ramps and elevators, for example. Movement tends to be a long, straightforward and uniform in the passage type. It usually works as space that serves or feeds other spaces.

Junction: Space at doors, windows and other kinds of openings including those that are designed to have the quality of changing points such as a group of columns. Movement tends to be abrupt, quick and fragmented. It usually works as a connection between different types of movement.

Place: Space of rooms, halls and other kinds of enclosure that allow assembly of movement. Movement tends to be complex, convoluted and sometimes stops. It usually works as served space which means that it is usually located at the end or the beginning of moving sequences.

From the Experiential dimension analysis, comparisons can be made between buildings. For example, the more passage-type space the quicker the average speed of movement inside the building or the more junction-type space the more sectioned and fragmented the movement or the more place-type space are in the building the higher the possibilities of creating rich identities in movement or functions, etc. The formulation of comparisons depends on design questions and problems that need to be solved; in this way, it is information to *'think with*.'

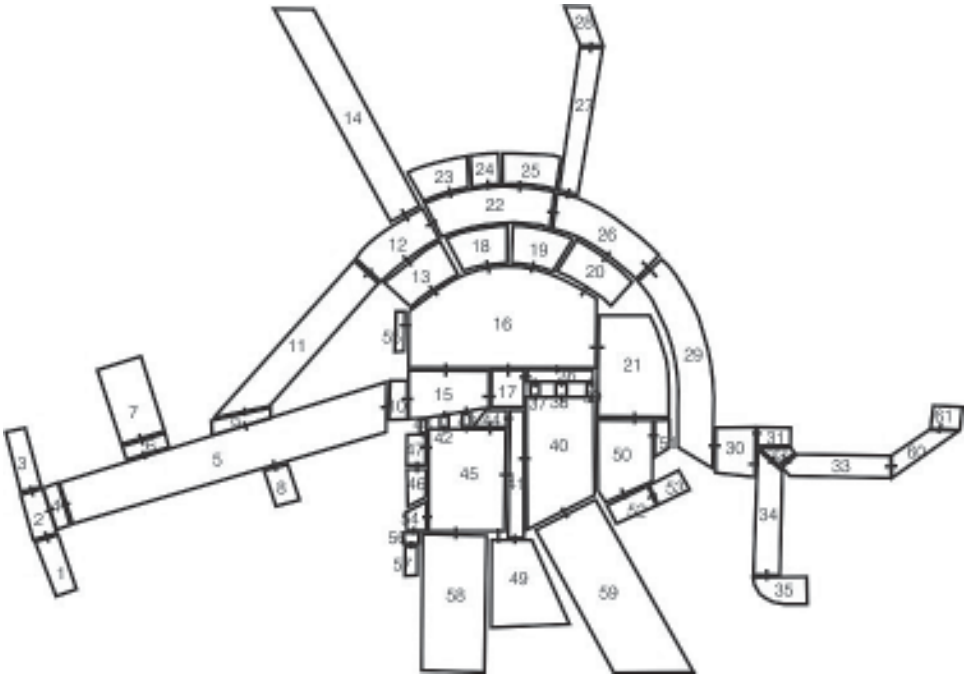


Figure 10 Convex space of King's Cross Underground station, ticket hall level

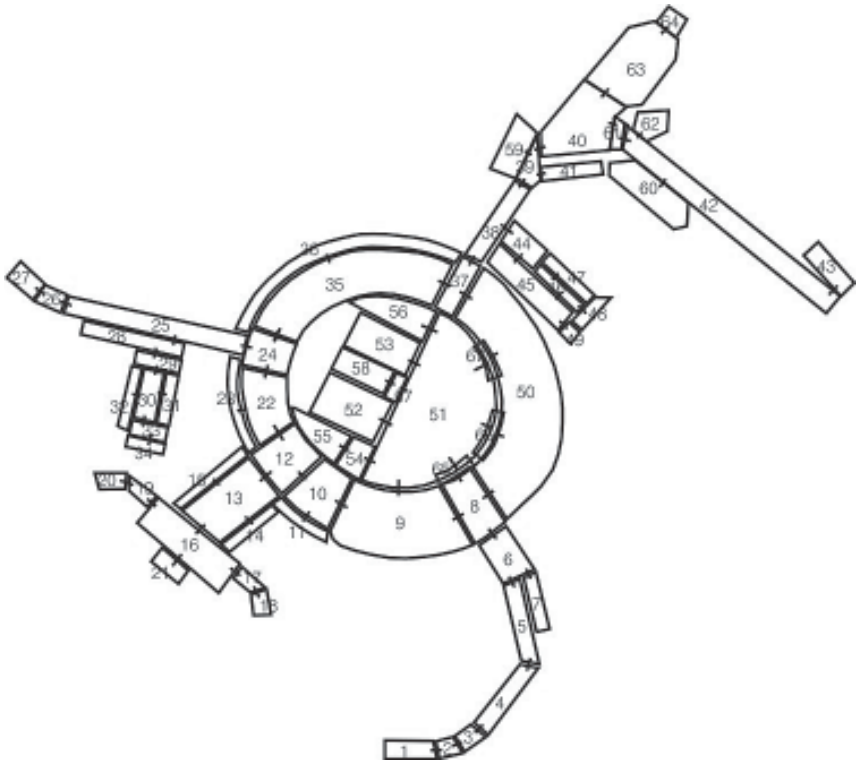


Figure 11 Convex space of Piccadilly Circus Underground station, ticket hall level

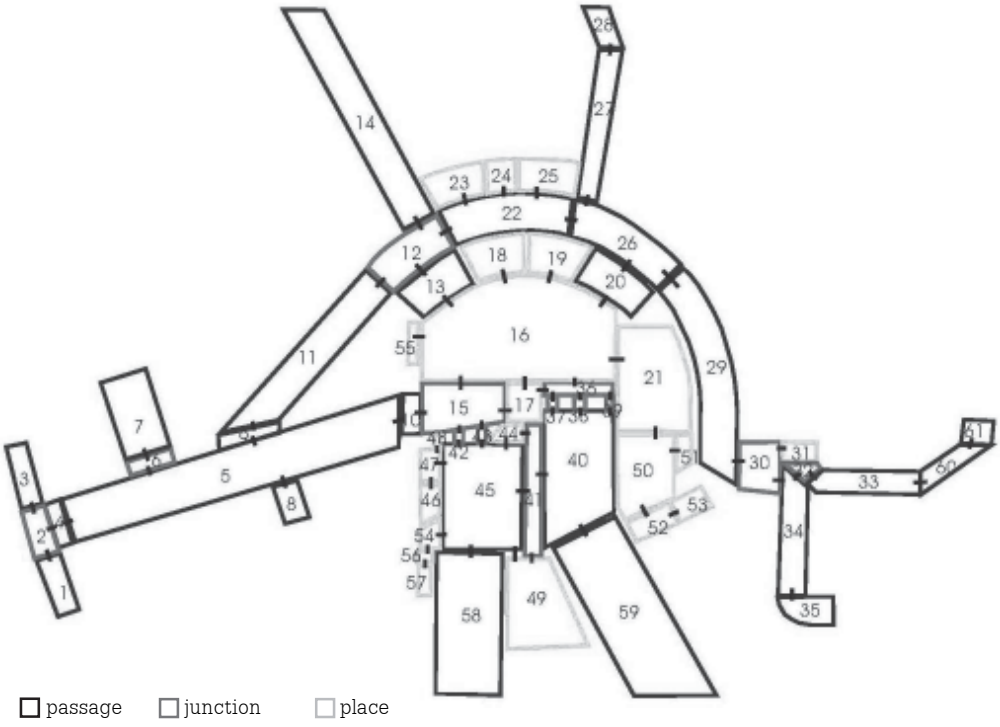


Figure 12 Convex space of King's Cross Underground station, ticket hall level

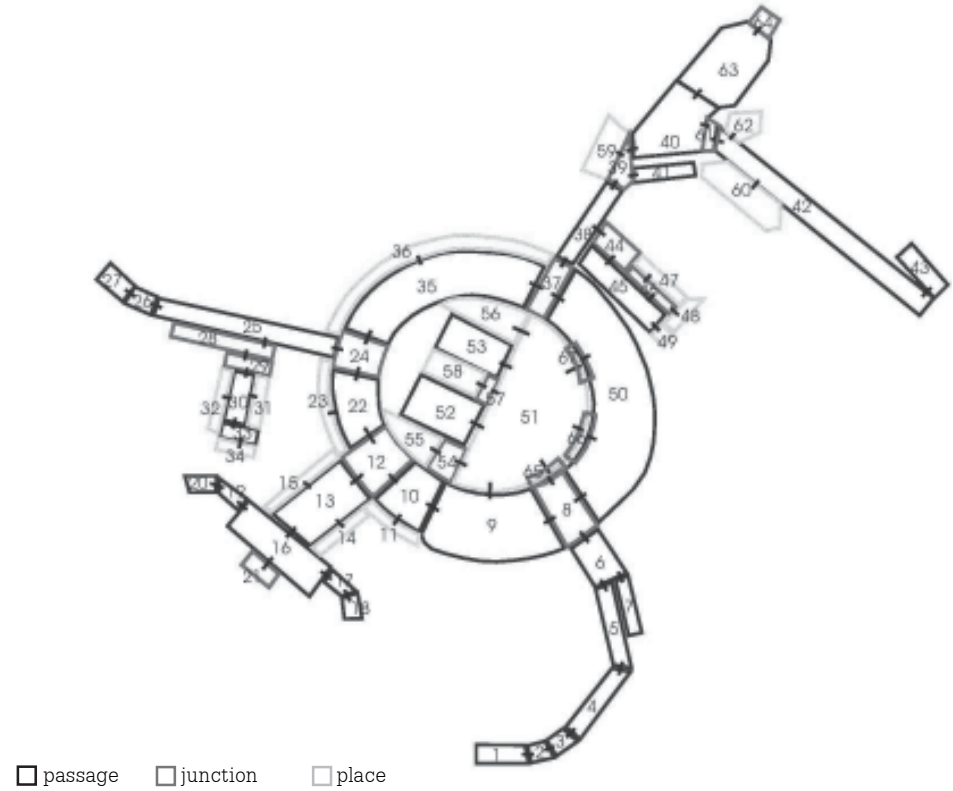


Figure 13 Convex space of Piccadilly Circus Underground station, ticket hall level

Experiential dimension will be superimposed on convex spaces drawn from buildings or design schematics. Passage type is coded in blue, Junction in red and Place in yellow. Figures 12 and 13 illustrate the Experiential dimension of King's Cross and Piccadilly Circus Underground stations.

Convex space is drawn up over building plans in order to establish the relationship between pieces of convex spaces which can be shown as a Justified graph with Hillier's space types; this graph is referred to as the Structural dimension of space in Relational Syntax. From on-site observations, Experiential, Functional and Architectural element will then be superimposed onto the Structural dimension (Figure 14).

3. Relational Syntax

At this stage, buildings can be understood as sets of 'relations' which are given various connotations and values by people's social and natural movement in the buildings. The Convex maps and Justified graphs above offer an understanding of relations between the Structural and Experiential dimensions in buildings. In using buildings, these two dimensions will be related to activities (what people do in space) and physical settings (what people see in space). The Functional dimension describes activities people do in space while the Architectural element dimension illustrates the physical settings people see in using buildings; i.e. people move from one point to the other (circulate) in a linear walkway space (corridor). For example, there are 'ticket hall', 'toilet', 'shop', 'circulation', 'office' and 'entry/exit' in the Functional dimension while there are 'hall', 'room', 'corridor' and 'gateway' in the Architectural element dimension [17].

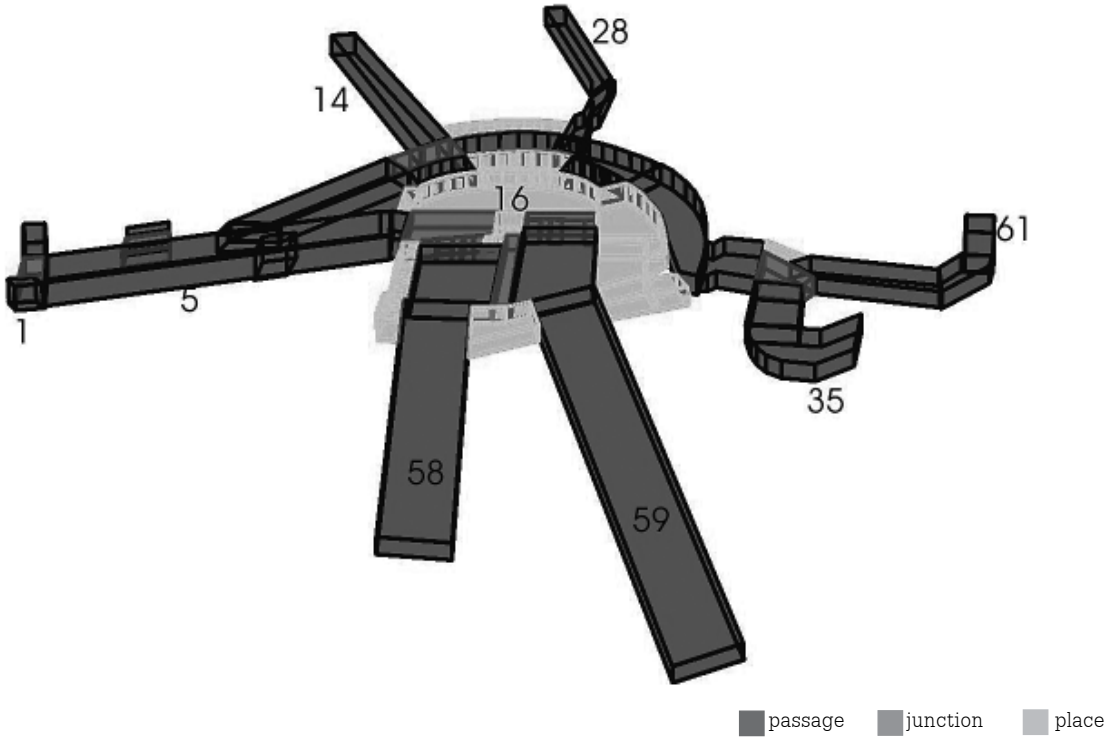
From the Structural dimension we can quantify the degree of 'efficiency' a space relates to other spaces by calculating the 'integration' values of each node in a Justified graph as well as identified each node with Hillier's space types [18]. The Experiential dimension describes how space is moved through. How space is used and perceived by users is explained in the Functional and Architectural element dimensions, respectively. The relations between these dimensions, Relational Syntax, can be shown as in Figure 15. Examples of syntaxes provided are written in a form of relations or 'scripts' with an order of Structure-Experiential-Functional-Architectural elements dimension.

Relational Syntax are therefore sets of 'relations' between Structure-Experiential-Functional-Architectural element dimensions which are linked to one another by movement [19]. In a building, there are many Relational Syntaxes that represent relations in three levels: first level inside the 'script' of each Relational Syntax itself, second level between 'different scripts' or different Relational Syntaxes and third between certain 'sets of scripts' or sets of Relational Syntaxes. These interactions make total understanding of the built environment; it becomes intelligible matter.

It is extremely important for architects to thoroughly understand these 'relations' and consequently they will be able to design, assess and improve existing buildings with greater in-depth information in regard to these 'relations.' Relational Syntax provides firstly the understanding of the built environment and secondly the analytical method for designing and analysing buildings space. However, to be able to design, Relational Syntax needs to be planned which means *a certain set of needs* will have to be converted into elements in Relational Syntax.

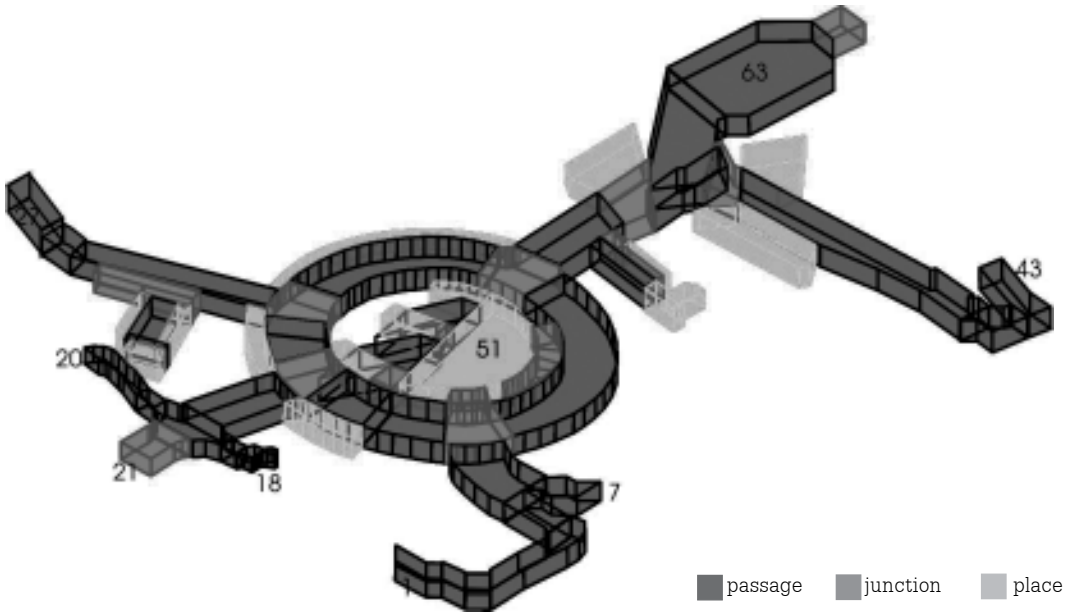
Figure 14 A-B Justified graph with Experiential dimension of King's Cross (A) and Piccadilly Circus (B) Underground stations (refer to each space by its number which relates a node in the graph to a space in the plan, for example no. 51 above is the same space as space 51 in Figure 12)

The Structural dimension of space '...an **a-type** space has one connection to and from it, a **b-type** has two connections: one connection is from other spaces and the other is to an a-type space or isolated groups of sub-complex spaces, a **c-type** space has two connections or more and has to be a part of a ring (a complete roundabout of connected cells) and a **d-type** space has three connections or more and has to be on the intersection point of at least two rings [18].'



A

Examples of Relational Syntaxes: 1 = d-passage-circulation-stairs/ 5 = d-passage-circulation-corridor/ 14 = d-passage-circulation-corridor/ 16 = d-place-ticket hall-hall/ 28 = c-passage-circulation-corridor/ 35 = d-passage-circulation-stairs/ 58 = c-passage-circulation-escalator/ 59 = c-passage-circulation-escalator.



B

Examples of Relational Syntaxes: 7 = d-passage-circulation-stairs/ 18 = c-passage-circulation-stairs/ 20 = c-passage-circulation-stairs/ 21 = c-junction-circulation-stairs/ 43 = c-passage-circulation-stairs/ 51 = d-place-passenger hall-hall/ 63 = c-passage-foyer-hall.

Figure 15 A-B Relational Syntax of King's Cross (A) and Piccadilly Circus (B) Underground stations

A certain set of needs can be treated as a 'script' for Relational Syntax. A 'script' is either project requirements from clients and/or existing information of all related physical factors from a building site. Such information is not necessarily all architectural. As in its general meaning, a 'script' is *a guideline or detailed descriptions of events* (usually including many things from the very substantial to the trivial); structure-experiential-functional-architectural elements information is therefore one kind of script. To different design questions, different scripts could be produced by and in the forms of relations of Relational Syntax. In this way, a 'script' could be used by architects to navigate through all related requirements of the design.

Relational Syntax uses concepts of Convex space to locate 'parts' of space and uses Experiential dimension to configure these parts so that they are intelligible to people movement. Finally, by relating such information with functions and architectural elements a design or building can be created or navigated based on detailed understanding of scripts which comes from questions, needs or problems in each design or analytical circumstances. For instance, 'scripts' can be extracted from the present conditions of King's Cross and Piccadilly Circus stations as follow:

King's Cross:

- Conditions/needs: Effective system to draw and spread movement using outer 'ring' spaces (no.11, 12, 22, 26, 29) which are integrated with subways. The 'ring' is a passage-type space perforated with junction-type spaces. It wraps around the ticket hall.
- Scripts:
  Syntax 11: c-passage-circulation-corridor
  Syntax 12: d-junction-circulation-corridor
  Syntax 22: c-passage-circulation-corridor
  Syntax 26: d-passage-circulation-corridor
  Syntax 29: c-passage-circulation-corridor
- Conditions/needs: The Ticket hall is divided into two parts: before and after the passimeters. The bigger part has a half-circle form. It is the largest Convex space.
- Scripts:
  Syntax 15: d-junction-ticket hall-hall
  Syntax 16: d-place-ticket hall-hall
  Syntax 40: d-passage-passenger hall-hall
  Syntax 45: d-passage-passenger hall-hall
- Conditions/needs: Clear sequence of space, there are strong visual and accessible directions such as the axis from the main escalators towards the subway to St. Pancras and Pancras road.
- Scripts:
  Syntax 12: d-junction-circulation-corridor
  Syntax 13: c-passage-circulation-stairs
  Syntax 14: d-passage-circulation-corridor
  Syntax 15: d-junction-ticket hall-hall
  Syntax 16: d-place-ticket hall-hall
  Syntax 45: d-passage-passenger hall-hall
  Syntax 58: c-passage-circulation-escalator
- Conditions/needs: Different levels between the ticket hall and the outer circulation ring create strong junctions. These junctions, in turn, create 'gateway' experience.
- Scripts:
  Syntax 12: d-junction-circulation-corridor
  Syntax 13: c-passage-circulation-stairs
  Syntax 20: c-passage-circulation-stairs
  Syntax 26: d-passage-circulation-corridor

- Conditions/needs: The inner part of the ticket hall works as a buffer between the escalators and the outer hall. It also acts as a brief gathering space for making decisions and orienting movement.
- Scripts:
  Syntax 40: d-passage-passenger hall-hall
  Syntax 45: d-passage-passenger hall-hall
- Conditions/needs: Most connections (subways) are given proper volume according to the actual volume of movement (Tables 1-2). The most crowded is the Metropolitan Line connection which is easily reached from the ground level.
- Scripts:
  Syntax 1: d-passage-circulation-stairs
  Syntax 2: d-junction-circulation-stairs
  Syntax 3: c-passage-circulation-stairs
  Syntax 4: c-passage-circulation-stairs
  Syntax 5: d-passage-circulation-corridor
  Syntax 6: c-junction-circulation-stairs
  Syntax 7: c-passage-circulation-corridor

Overall Script characteristics:

Configured for 'departure' or junction or passage-type where movement perpetually circulates (*syntaxes: 11-12-22-26-29*). It has an effective use of sub-circulation system (*syntaxes: 12-13-20-26-15-16-40-45*) that is well integrated with subways (e.g. *syntaxes: 1-2-3-4-5-6-7*).

Piccadilly Circus:

- Conditions/needs: The Ticket hall rotates movement around the main core while the inner circle acts as the generator and receiver of all movement.
- Script:
  Syntax 50: d-passage-ticket hall-hall
- Conditions/needs: The outer circle acts as the distributor. It is mostly made of passage-type space and its configuration describes a simple and full circulated movement with series of junction spaces along its path.

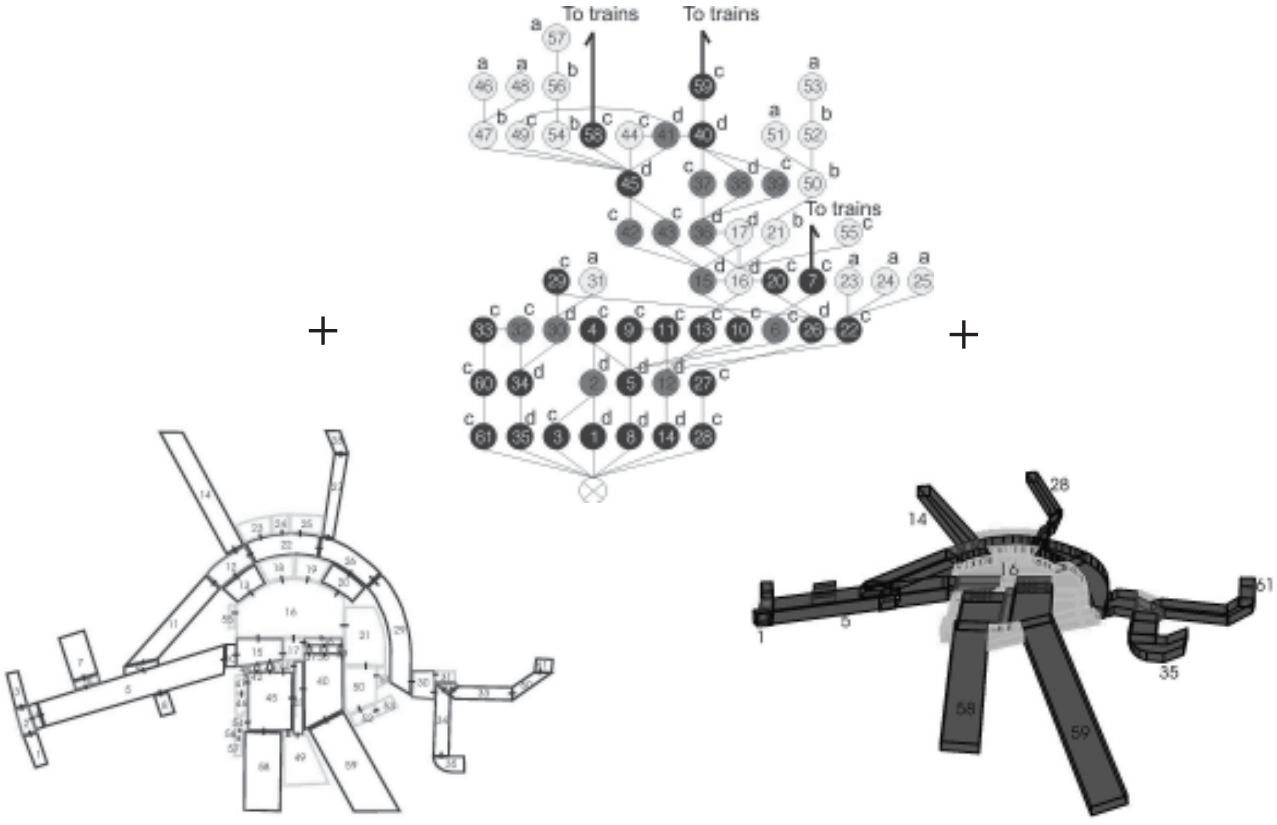


Figure 16 Understanding 'script' of King's Cross Underground Station:
Convex analysis (social space) + Experiential structure of space (movement) + Relational Syntax (built environment)

- Scripts:
  Syntax 8: d-junction-ticket hall-hall
  Syntax 9: d-passage-ticket hall-hall
  Syntax 10: c-passage-circulation-hallway
  Syntax 12: c-junction-circulation-hallway
  Syntax 22: c-passage-circulation-hallway
  Syntax 24: d-junction-circulation-hallway
  Syntax 35: c-passage-circulation-hallway
  Syntax 37: d-junction-circulation-hallway
  Syntax 50: d-passage-ticket hall-hall
- Conditions/needs: The largest Convex space, the half circle space (no.51), gathers and spreads movement in its radius directions.
- Script:
  Syntax 51: d-place-passenger hall-hall
- Conditions/needs: Subway no.2 receives the smallest volume of movement (Tables 3-4) but offer many possibilities of movement. It should attract more movement.
- Scripts:
  Syntax 1: c-passage-circulation-stairs
  Syntax 2: c-passage-circulation-corridor
  Syntax 3: c-passage-circulation-corridor
  Syntax 4: c-passage-circulation-corridor
  Syntax 5: d-passage-circulation-corridor
  Syntax 6: d-passage-circulation-corridor
- Conditions/needs: Subway no.4 seems to be the most crowded but has small space. It is located near attractions of the area (London Pavilion and Trocadero).
- Scripts:
  Syntax 38: c-passage-circulation-corridor
  Syntax 39: d-junction-circulation-corridor
  Syntax 40: d-passage-foyer-hall
  Syntax 63: c-passage-foyer-hall
  Syntax 64: c-junction-foyer-hall
- Conditions/needs: The escalator shafts to the underground have strong presence in the ticket hall. It is well connected to the ticket and passenger hall space. Only two turns are needed before descending to the trains.
- Scripts:
  Syntax 52: c-passage-circulation-escalator
  Syntax 53: c-passage-circulation-escalator

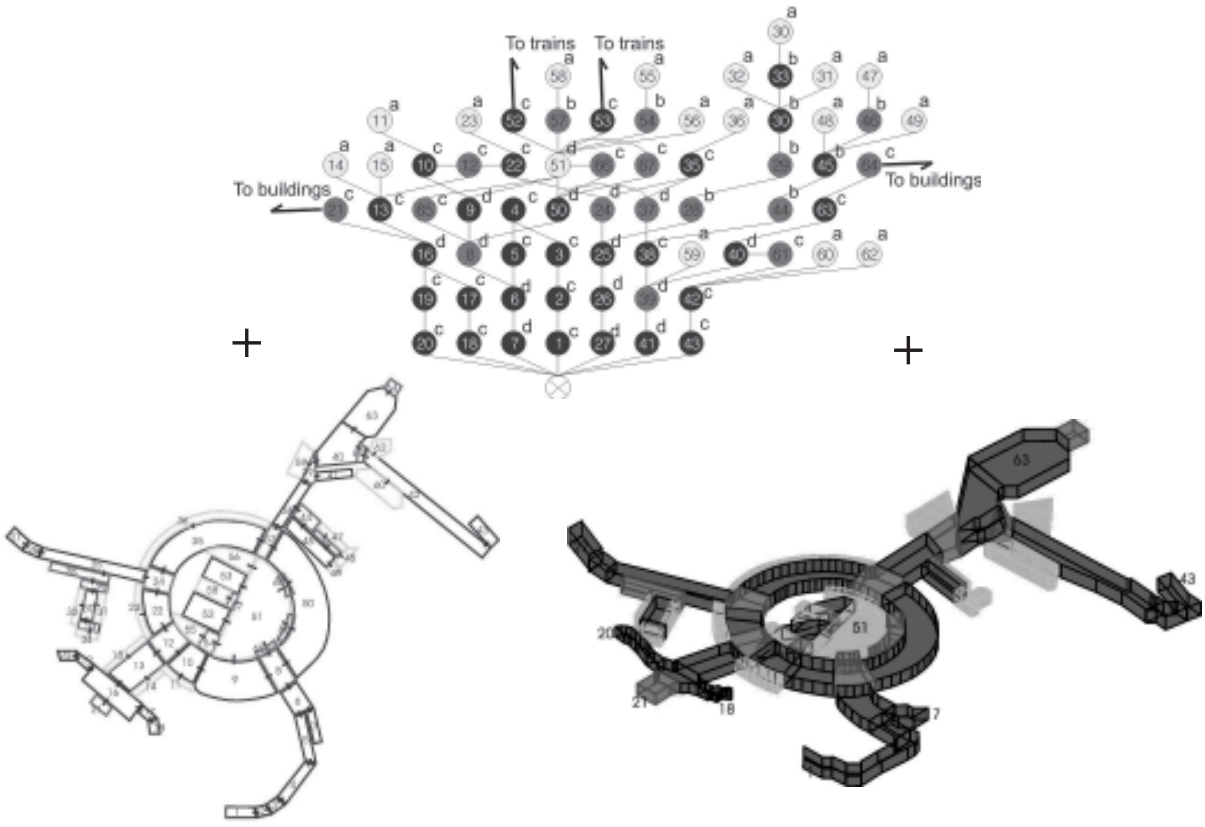


Figure 17 Understanding 'script' of Piccadilly Circus Underground Station:
Convex analysis (social space) + Experiential structure of space (movement) + Relational Syntax (built environment)

Overall Script characteristics:

Strong integration between ticket hall level and underground level using size and location of space (*syntaxes 50-51-52-53*). Achieve 'plaza' character through circular movement of ticket hall (*syntaxes 8-9-10-12-22-24-35-37-50*) and integration with buildings (*syntaxes 1-2-3-4-5-6-38-39-40-63-64*). Well recognized as the 'arrival' or place-type space (*syntaxes 50-51*).

Conclusion

It is argued here that the 'script' can be arrived at either from an analytical approach (on existing buildings) or from the design end (on conceptual space). Conditions and needs can be both information and objects from which scripts are generated or extracted. The concept is bi-directional as buildings can be understood as spatial relations and space can be configured as the built environment.

The objective of this article is also bi-directional: as a script of a specific design and analytical methodology and as conditions of specific pieces of architecture. The case studies of the two stations serve as simpler versions of the Relational Syntax methodology in both analytical procedures and design applications. As a whole, the stations share some similarities as transportation hubs which promote fast and direct movement between three levels: ground, subsurface or ticket hall and underground. Further analysis can be made according to topics of interest using either syntactic values [20] or on-site phenomena or both. The buildings discussed have very clear purposes and functional engagements as places for movement. Such buildings are simpler in the way people experience space in socio-cultural activities than, say, museums however stations or terminals have come to have a bigger and more important presence in people's everyday life.

Further development in making an application that can provide rigorous tests and interactive methods using movement to navigate design activities is being investigated. Theory discussed above is being developed into software for architects to 'think with' in their design activities. Therefore, the conclusion of the article is really an introduction to the concept of Relational Syntax and script approach. At this stage, it is hoped that this theoretical construction will provide well-balanced support for the efficient coexistence of intuitive design and intelligible analysis in architecture.

References

[1] Relational Syntax is a theoretical procedure used to explore relations between the four spatial dimensions of a building these are: Structural-Experiential-Functional-Architectural element. Relational Syntax considers qualitative factors in space such as types of bodily movement, types of usages in space and types of building parts and relates them to the quantitative integration value of space based on Space Syntax theory of spatial configuration. Suvanajata, R. (2000). Relations in Architectural Space. Unpublished PhD. Thesis. London: University of London.

[2] The concept of script recalls similar notions as those that are used in choreography and film directing. Sequences, meanings and frames of reference are among the most important factors in understanding and designing dances and films as in works by Rudolf Laban's and Sergei Eisenstein. It is argued here that the design and analysis of architecture will benefit from the script notion in which Relational Syntax provides sequences, meanings and frames of reference in architectural space while the scripts illustrate the relationship between various relational syntaxes.

[3] Piccadilly Circus Underground Station is located underneath one of the world's busiest plazas while King's Cross Underground Station serves as the terminal for different train systems for London and the southeast region of the UK.

[4] Lawrence, D. (1994). Underground Architecture. Middlesex: Capitol Transport Publishing.

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[6] Market Report: October 1996 (1996). London: London Transport Marketing.

[7] The concept of the Experiential dimension in architectural space is associated with bodily movement in building. There are three types: passage, junction and place. Suvanajata, R. (1995). Instrument of Dynamism. Unpublished Master of Architecture Thesis. New York: Pratt Institute.

[8] It is argued that in architectural space the Architectural elements dimension exists in which architectural objects are seen as being independent from qualities in other dimensions. Suvanajata, R. (2002). Relations in Architectural Space: Designs and Effects in Space of the Traditional Thai Houses and Temples. Journal of Architecture Chulalongkorn University. Bangkok: Faculty of Architecture Chulalongkorn University.

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[13] From a draft paper by Charles Holden entitled Aesthetic Aspect of Civil Engineering (26 April 1944). The quote is cited in Lawrence, D. (1994) Underground Architecture. Middlesex: Capitol Transport Publishing.

[14] Eisenman, P. (1987). Misreading. Houses of Cards. Oxford: Oxford University Press.

[15] Koolhaas, R. (1995). Anyplace. Cynthia Davidson (ed.) Massachusetts: The MIT Press.

[16] Suvanajata, R. (2000). Relations in Architectural Space. Unpublished PhD. Thesis. London: University of London.

[17] It is argued here that people associate concepts of usage and objects in different 'folders' of vocabularies. However, the distinctions between the two may not be intuitively obvious but analytically categorised. The criteria employed in Relational Syntax to differentiate the two realms are 1) the Architectural element dimension is the building parts that perform usages in the Functional dimension e.g. a corridor facilitates circulation; 2) the fundamental meaning of the words used, i.e. in the Architectural elements dimension the words must specify objects and in the Functional dimension they must specify actions.

[18] There are four space types in the Structural dimension of space. According to Hillier (1996), an a-type space has one connection to and from it, a b-type has two connections: one connection is from other spaces and the other is to an a-type space or isolated groups of sub-complex spaces, a c-type space has two connections or more and has to be a part of a ring (a complete roundabout of connected cells) and a d-type space has three connections or more and has to be on the intersection point of at least two rings Suvanajata (2002). The justified graph concept and calculations were originally described in Hillier, B. & Julienne Hanson (1984). Social Logic of Space. Cambridge: Cambridge University Press.

[19] Suvanajata, R. (April-May 2002) Research in Designing Architecture. Journal of Association of Siamese Architects. Bangkok: ASA Publishing, 102-110.

[20] Hillier, B. (1996). Space is the Machine. Cambridge: Cambridge University Press.