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UNDERSTANDING MUSEUM MAPS AS DEVICES FOR EMBODYING DISCIPLINARY KNOWLEDGE AND IMPACT ON VISITORS' BEHAVIOURS

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Abstract

This research aims to investigate how to define museum maps, to what degree they relate to curatorial intents, and how they affect visitors' behaviours. Two case studies were carried out to explore the theoretical relation between graphic properties and architectural or curatorial propositions, and to discover meaningful differences among visitors' movement behaviours using string-matching technique to analyse data of about 200 subjects interviewed and individually traced for the first twenty minutes from entry points. From analytical and empirical studies, we argue that museum maps can be understood as focusing devices of embodying curatorial intents through distinct graphic styles, aiming not only to deliver spatial knowledge but also to make underlying disciplines visible. They can act as a discourse, and they affect visitors' behaviours. However, there are fundamental distinctive patterns according to graphic styles, different types of spatial information, configurational features, and demographic factors (mainly familiarity and motivations). If non-motivated novices are in a predictable environment and given a map mainly concerned with topographic properties, their behaviours are determined by attractive features described on the map so that they move around in a structured way. In contrast, if they are in an unintelligible layout and provided a map focused on topological information only, their movement patterns are strongly associated not with the graphic properties, but with the configurational features or exhibits. On the other hand, experienced visitors, irrespective of intelligibility or graphic styles, tend to construct their own itineraries by actively interacting with maps, and also they would like to move at first to the floor on which their destinations would be placed.

Keywords: *Space Syntax, Curatorial Intents, Museum Maps, Movement Patterns, String-matching Technique*

Theme: *Building Morphology and Performativity*

1. Introduction

This research aims to understand museum maps not as a supporting device for describing spatial knowledge but as a focusing device for embodying curatorial intents of museums or galleries, and to suggest a fundamental relationship between graphic styles and museum buildings. Also, it attempts to develop an appropriate method of comprehending visitors' behaviours in relation to demographic factors, distinct types of spatial knowledge on maps, and configurational features. Museums are widely understood as a building of shaping or establishing disciplines by a means of drawing things together, setting them apart, or structuring (i.e., sequencing) them to represent expert knowledge or curatorial intents (Hooper-Greenhill 1992; Walsh 1992); or as a social space because they offer the chance of observing one another through not the physical interactions but co-presences or co-awareness (Bennett 1995). Museum studies, therefore, have been primarily concerned not only with the relationship between spatial configurations and movement patterns or social encounters (Huang 2001; Choi 1999), but also with exploring how the layout of space is related to the art of exhibiting (Tzortzi 2007) or social and pedagogic implications (Pradinuk 1986; Peponis and Hedin 1982). Thus, it suggests that the spatial organisation plays a significant role either in constructing new knowledge through weak classification and framing of spaces and objects, or in reproducing a pre-defined meaning from firmly insulated classification and strong walking sequence. However, it has not yet explored to understand museum maps from those perspectives. How and to what extent do maps, randomly given to visitors in museums, relate to curatorial intents? Or, in what way do they make expert knowledge visible through organising graphic components? How do they relate to configurational properties? How do they influence visitors' movement patterns? These are the key questions in this study.

2. Understanding maps

According to MacEachren (2004), there are two levels in understanding map representations: the one is the *private/perceptual (or cognitive) level*, and it is mainly dealt with how individual sees and interprets individual symbols and maps; and the other is the *public/social level*, which is concerned with developing logical systems for creating meaningful representations and understanding them in a broader context. The private level is directly related to the issues of the process of generalisation (i.e., 'quality'), or legibility of maps from the aspect of Prägnanz (i.e., 'good' forms); whereas, the public domain plays a key role of setting out ways of what to select and how to relate in order to speak of social meanings. While the former is to look at how maps are seen, the latter focuses not only on generating *meanings in maps*, which are directly related to the individual sign relations and logical interrelationships (e.g., information about when, where, and what through interpretation), but also on imposing *meanings of maps*, which speak of social discourse of which the map is a part (e.g., place, era, and subject). Thus, maps stand for facts, systems of propositions, and arguments about what the world might be (Wood 2010), and we can think of the map as a description of our society.

No doubt that there have been a huge number of studies regarding maps. For instance, Levine (1982) contends that coordinate labels, asymmetrical structure, and forward-up equivalence affect the usefulness of maps from a psychological viewpoint. Arthur and Passini (2002) mention the significant contribution of maps to construct our cognitive mapping and to understand spatial layouts. O'Neil (1991) reveals that signage (e.g., directional and textual signs) reduces wayfinding errors like wrong turns or backtrackings. Golledge et al. (1995) clarify that spatial knowledge obtained from maps is superior rather than that through navigation (or direct experience). As a result, they prove that maps enable us to overcome difficulties of navigations or orientations through procedural knowledge, and also to comprehend the overall spatial information (or survey knowledge) by mapping. Despite the positive effects of maps in terms of solving spatial problems, little research has been undertaken to understand them as a *focusing device* of embodying cultural or social propositions within the given built environments. In other words, they have attempted to examine how maps would help readers to learn and construct spatial knowledge at the personal level, and they have hardly investigated the maps at the public level. Therefore, this study examines specifically how maps reflect curatorial intents in museum buildings, and the theoretical and methodological questions are as follows: 1) how can we define museum maps? 2) How can we demonstrate the reflective relationship between curatorial intents and graphic styles (or spatial knowledge)? 3) To what extent do the maps relate visitors' exploration? Can we identify distinct movement patterns in relation to the graphic properties? If so, are these behaviours correlated with visitors' demographic features (e.g., familiarity or motivations) as well as spatial morphology?

3. Ten codes to understand relationship between maps and curatorial intents

How can we describe meaningful properties or distinct styles of maps? What criteria might be used to clarify reflective relations of the maps to museum buildings? In (2010), Wood borrows the conception of Barthean Myth to clarify the close relation between social discourses and maps. Myth, according to Barthes (1972), is a type of *speech*, a system of communication, a message, a mode of signification, or a form, so that it is defined not by the object of its message, but by the way it represents the message. There are two functions: myth points out and notifies what it means at the language-object level, and then it makes us understand something and imposes it on us at the metalanguage level. From these aspects, Wood insists that maps work at the two levels as well: on the one hand, maps offer information about what kind of things are chosen at the semiological (or intrasignificant) level by constructing a visual analogue of phenomena, attributes, and spatial relations from the given environments through the following codes: *iconic* code, as inventories or fragmentations, defines things selected from all in an environment; *linguistic* is the one that identifies, names, or assigns to the things; *tectonic* is the code of finding, or getting there with topological relations and scalar (or metric) specifications; *temporal* refers to time, duration, or tense; and *presentational* code is dealt with ordering, arranging, or organising graphic components (e.g., title, legend, text, diagrams, colours, etc.), so as to achieve speech or a level of discourse.

Maps can speak of a system of the selections at the mythical (or extrasignificant) level. They serve *social and cultural issues to which the map speaks* (MacEachren 2004). Thus, they use a particular style to connote a fundamental point of view on the world, and what they stand for is addressed by the following codes: *thematic* code, which establishes the domain of discourse; *topic* that turns from space to place, gives its subject, names it, sets it off from other place, and asserts its existence; *historical* that works only on the time, which is established the temporal code, so that it signifies an era or a certain history; *rhetorical* sets the tone like values, cultures, or societies; and *utilitarian* code that serves any purpose. Based on these intra- and extrasignificant codes, Wood clarify that a map "act as a focusing device between these two planes of signification, gathering its internal or constituent signs and offering them up collectively as the system of propositions that is the map". At the level of language, signs work to "construct a visual analogue of meaning" to construct and transmit, for example, collections or exhibitions in museum buildings; while, at the mythical level, signs "refer to themselves and their makers", so as to lead readers to understand underlying values, ambitions, or intentions (Wood 2010, 86). Therefore, these ten codes are regarded as key criteria to identify graphic properties, and they are used a set of tools to examine the reflective relation between museums' propositions and graphic styles.

4. Do museums' maps relate to curatorial intents?

Two museums, the Natural History Museum and the Science Museum in London, were selected. Spatial layouts were examined through space syntax tools (e.g., visibility, accessibility, and isovists), and then key analytical ideas were used to understand the relation between spatial organisation and underlying disciplinary knowledge: for example, 'intelligibility' (Hillier 1996) can be thought of as a means to explore whether the local-global relationality would lead us to transpatial knowledge through cross-referencing or inter-relation structure of exhibitions; and 'spatial typologies' can be used to determine how strongly galleries might be framed by calculating *c-sequenceLength(Mean)* and *c-sequenceDepth(Mean)*, or how many choices could be given by indexing *d-ringMean* (Tzortzi 2007). Note that two layouts of each museum (i.e., the original and present ones) were analysed.

The Natural History Museum ("NH"), London

The key concept of shaping the layout of spaces and collections in the original layout of the NH in 1883 (figure 1) was both *classification*, referred to as an expertise way of placing identities in the conceptual structure of divisions, and *demarcation*, meant a strict relegation between the living and the extinct species (Forgan 1999; Yanni 1999; Psarra 2009). Specimens were arranged in a highly structural way according to their physical characteristics and the degree of complexity at first, and then they were configured again regarding to the relative size compared with each other. For example, the complex and large species, such as 'Birds' or 'Fish', were filled in the front gallery of the west wing or the rear one next to the Index Hall; whereas, the simple and small ones like 'Shell' or 'Star Fish' were in the most peripheral ones. In contrast to the strong classification, the walking sequence was very weak. There was no any pre-defined or curatorial route, but rather the spatial structure allowed visitors to move freely due to d-spaces, long ranged visual fields, and symmetric visual shapes. The synchronic view was the key characteristic to understand the collections as well as the spaces, and as a result it led visitors to delineate the totality of natural history by "the act of looking" (Yanni 1999) through the cross-referencing and inter-changeable structure.

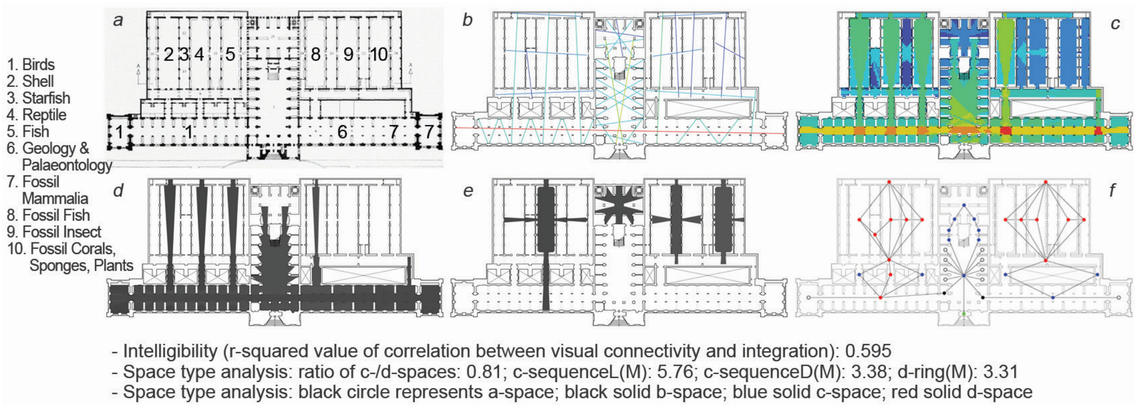
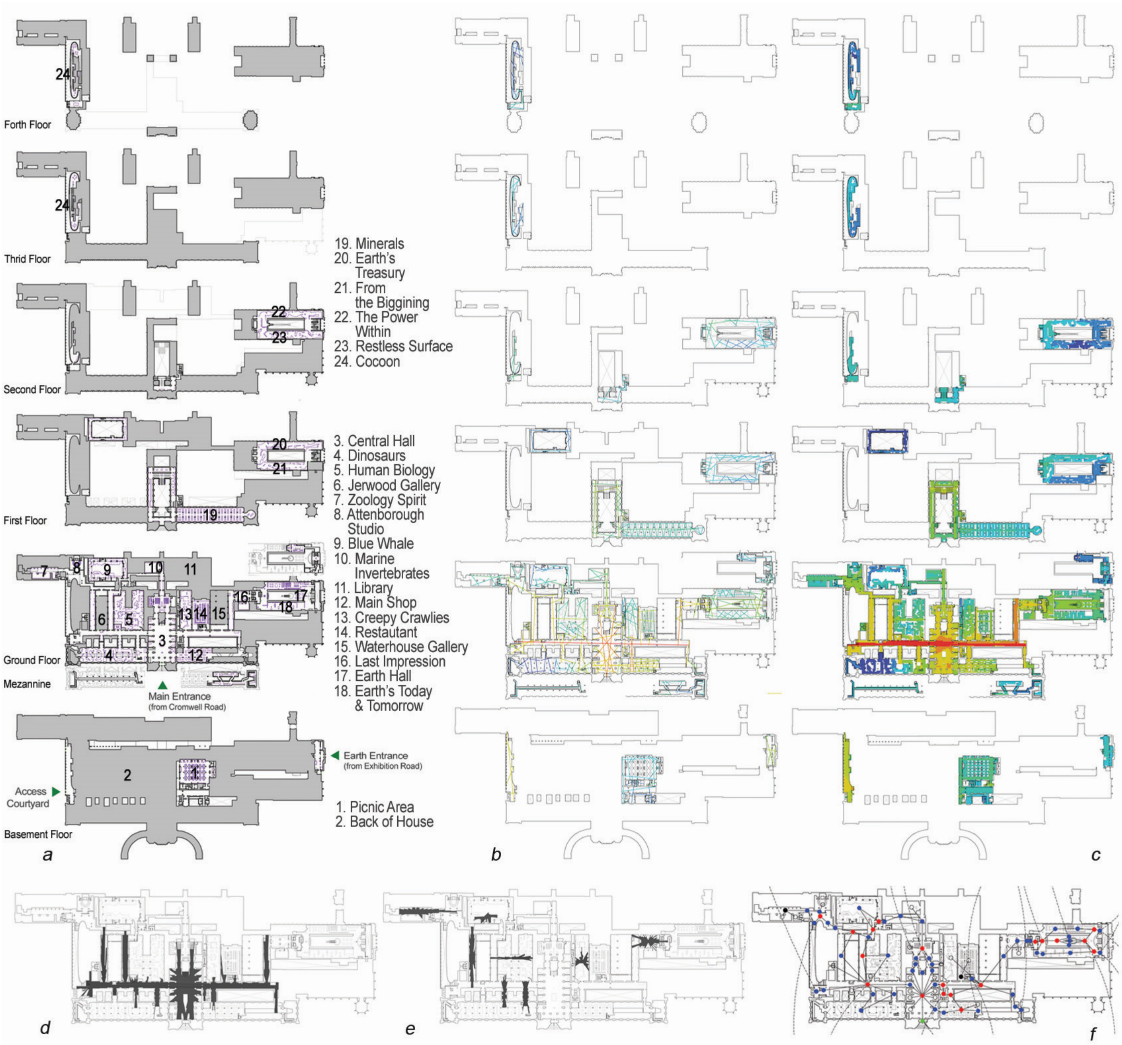


Figure 1: Original layout of the NH in 1883 (*a*: floor plan; *b*: axial line graph with integration values (r:n); *c*: visual integration; d: line isovists; e: isovists from selected galleries; f: space type analysis)



- Intelligibility (r-squared value of correlation between visual connectivity and integration): 0.408
- Space type analysis: ratio of c-/d-spaces: 2.48; c-sequenceL(M): 5.54; c-sequenceD(M): 3.46; d-ring(M): 2.45
- Space type analysis: black circle represents a-space; black solid b-space; blue one c-space; and red d-space

Figure 2: Present layout of the NH in 2011 (a: floor plans; b: axial line graph with integration values (r:n); c: visual integration; d: line isovists; e: isovists from selected galleries; f: space type analysis)

It is quite obvious that the museum has been transformed in various ways (figure 2): the most significant change was to set out what to show to the public and how to educate them. Instead of displaying all objects, they were carefully divided into two categories: 'show-collection' for *entertainment* which would be displayed in 'front of house' (Penn et al. 2007); and 'study-collection' for *research* which would be investigated by scientists in 'back of house'. Definite facts or scientific knowledge of the show-collections, then, were clearly stated on an easily-read *label* (Stearn 1981). Secondly, natural history was replaced with biology, concerned with specific correlations of different organisms based on evolutionary theory, genetics, or biochemistry (Foucault 2002; Marcus 1993). It means that the hierarchical structure (e.g., classification and demarcation) no longer exists in the present layout, but rather it is focused on particular species, themes, or content frames, such as, 'Human Biology', 'Our Place in Evolution', or 'Ecology'. The layout of space and object emphasises physical and didactic form of knowledge (Peponis and Hedin 1982) by a means of more fragmented or shortened axiality, short ranged visual fields, and varying depths in the galleries, so that the overall spatial structure becomes less predictable (the intelligibility of the present layout: 0.408; while 0.595 in the original). Lastly, the walking sequence becomes much stronger; for example, ‘Dinosaurs’, ‘Image of Nature’, ‘Human Biology’, ‘Ecology’, and ‘Creepy Crawlies’ have been converted to a- or c-spaces from d-space, and as a result the ratio of c-/d-spaces is greatly increased to 2.45 from 0.81 and in turn the d-ring(M) is decreased to 2.45 from 3.31. It means that, unlike the original layout, the act of looking is restricted by the firmly insulated spatial structure and the strongly linear walking sequence.

Figure 3: Floor plan map of the NH (above: the front page; below: the rear one, published in Aug. 2011)

Ten codes were used to investigate the map of the NH (figure 3), and key features were as follows: 1) different types of symbols are used: *standard* symbols, describing ancillary functions with locative assertion (e.g., café, shop, info-desk, lifts, or entrances); *intuitive discourse* symbols, referring to exhibitions drawn by the physical characteristics of selected species (e.g., T. Rex for ‘Dinosaurs’ or falling rocks ‘Restless Surface’); *logical discourse*, signifying other exhibitions depicted by social or cultural products (e.g., cylinders for ‘Zoology Spirit’, picture frame ‘Image of Nature’, or clock ‘From the Beginning’) and explained in legends; and lastly, *neutral discourse*, defining nothing but locative information about special exhibitions like Waterhouse or Jerwood gallery. 2) These symbols are once again categorised into *four colours,* green, blue, red, and orange, and more interestingly the zones combine the idea of buildings and divergent methodologies for preservation together. For example, the red zone indicates the Earth Gallery, its autonomous circulation system, and distinctive themes compared to other zones; while the orange zone signifies the Darwin Centre, a way to ‘Cocoon’, and collections which are stored in spirit or dried out. However, the green and blue zones do not designate buildings, themes, or preservation, but rather the old-fashioned idea of the demarcation is used to represent the two wings. Although it no longer plays any role in determining layout of objects, it is still considered as a key conception of addressing overall spatial structure or independent circulation systems to readers. 3) The floor plans do not offer any idea of ‘the back of house’ by eliminating the sacred or scientific spaces. 4) Although most galleries are firmly insulated to each other, some of them emphasise the transitional role within the local circulation systems, such as ‘Mammals’, ‘Fish, Amphibians and Reptiles’, ‘Fossil, Marine Reptiles’, ‘Birds’, and ‘Last Impression’. 5) The plans lead us to reconsider the spatial relationship between buildings: the Darwin Centre, for example, seems to claim to be independent from the Waterhouse’s building, while the Earth Gallery deliberately stresses the linkage to the main building by amplifying the gallery of ‘Last Impression’ and shrinking the exhibition area of ‘Birds’. 6) Linear perspective governs the floor plans, and it acts as a representational code since it organise graphic elements like legends and inset images. Generally, it is used to provide a depth clue (MacEachren 2004) from the cartographic viewpoint, or to create positional information (Holm 2010) from the architectural aspect. Thus, it can be argued that the plans enable us not only to obtain tectonic relationships through the sense of depth (or height), but also they lead to the paradigmatic form of the spatial consciousness by stressing frontality and symmetry of the main building. 7) *Inset images*, below the plans, indicate the most spectacular or valuable objects that are expected in this museum (e.g., ‘Diplodocus’, ‘T. Rex’, ‘Dodo’, ‘Giant Sloth’, or ‘Giant Sequoia’), and also they draw our attention to the architecture itself and raise scientific issues; for example, ‘Cocoon’ and a ceiling panel draw out attention to the architectural spectacles; ‘Climate Changes Wall’ claims the global issues; or Darwin statue represents the significant position in natural history.

The Science Museum (“SM”), London

The concept of the SM was addressed in the form of *prescriptive texts* (Markus 1987) in the reports issued by the Bell Committee (1910; 1911), and they clarified that the Museum should be the place not only of preserving remarkable appliances in terms of scientific progress and history, but also providing an easy access to a variety of audiences, ranged from young students to professional or non-specialist visitors. Thus, collections had to be ‘well laid-out’ and furnished with ‘suitable labels’ to create an *idealised microcosm* of science and technology (Nahum 2010). The committee claimed impossible classification or utilisation caused by crowding in the ‘National Museum of Science’ as the origin of the current SM, and suggested a new construction with the following criteria: *multi functions* to serve education, conference, and workshop; *direct access* to every space; *readable communication* between subjects (or exhibitions); and *open plan* galleries capable of displaying any size of objects. Unlike the detailed spatial structure, layout of objects was not described but overall arrangement of subjects across the building was mentioned: for example, ‘Astronomy’, ‘Geology’, and ‘Geography’ would be placed at the East end; ‘Mathematics’, ‘Physics’, and ‘Chemistry’ at the Eastern End; and the series of the applications of ‘Science in the Arts and Industry’ in the Central or Western Block. Interestingly, the layout of the subjects reflects to learning processes, from observing our environments, establishing principles, and to applying them into our daily life. Considering them, a new building was opened in 1928 (figure 4): in the East end, machines and tools used in mining or textile industry occupied the first floor; acoustical, thermal, and mathematical instruments relating to ‘Geophysics’ and ‘Meteorology’ occupied the second; and optical tools for ‘Photography’, ‘Astronomy’, and ‘Geodesy’ the top floor. In the western part, ‘Aeronautics’, ‘Electrical Engineering’, ‘Construction Engineering’, and ‘Chemistry’ were placed on the ground, first, second, and third floor respectively.

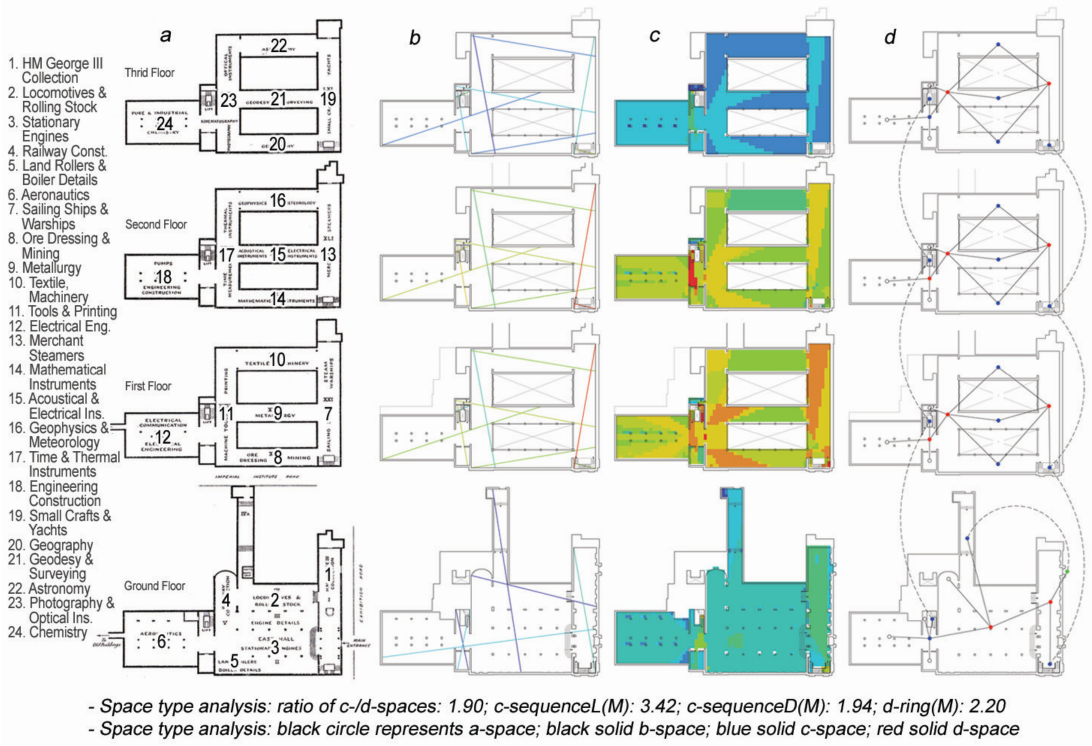


Figure 4: Original plan of the SM in 1928 (a: floor plans; b: axial line graph with integration values (r:n); c: visual integration; d: space type analysis)

Coming to the present layout (figure 5), the idealised microcosm was replaced with 'Knowing, Making and Using' principles and thematic or topological frames (Macdonald, 2002). The objects no longer belong to specific subjects, but rather they are regarded as *evidence* of social history in that they can be interpreted into "*multiple* meanings in different social or cultural contexts for different people" (Boon, 2010). The other major change is that the Museum is thought of not merely as the site of housing the objects collected in the past, but also it is the place to communicate with contemporary stances (i.e., present scientific issues) and the science of tomorrow. In other words, the dialectic between "the voices of the past" and "the needs of the present and the future" under a single roof is considered as a key curatorial intent (Ibid). 'Antenna' in the Wellcome Wing ("WW") provides the latest scientific ideas or news, or 'Who am I?' focuses on the contemporary medical, brain, and genetic science that leads to discover our body through interactive screens or playing games. In contrast, galleries in the Eastern ("EB") and Central Block ("CB") deliver social and historical meanings: for example, a series of iconic objects in 'Making the Modern World' stands for the chronological progress of industrialisation; engines or boilers in 'Energy Hall' explain the driving force for the British trade and industry; 'Challenge of Materials' demonstrates the diversity of materials used in different times and regions; or 'Ships' and 'Flight' give us the comprehensive knowledge through the typological collections. Thus, the simple and powerful axial lines in the original layout are replaced by shortened and fragmented ones; the integration core becomes deeper; and the walking sequence is much stronger (c-sequenceL(M): 5.12 and c-sequenceD(M): 2.92 in the present layout; whereas 3.42 and 1.94 respectively in the original), even though the ratio of c-/d-spaces and the d-ring(M) between the two layouts are barely changed (1.82 and 2.41 in the present; while 1.90 and 2.20 in the original). Moreover, the present axiality is strongly associated with the didactic form of disciplinary knowledge: for instance, 'Exploring Space' celebrates chronological events through a prominent axial line; 'Health Matters' explains impact of science and technology on our health by setting out objects along a strong axis; and the grid-like layout of ‘Who am I’, ‘Atmosphere’, ‘Ships’, or ‘Flight’ allow us to get a synchronic and comparative view across the galleries.

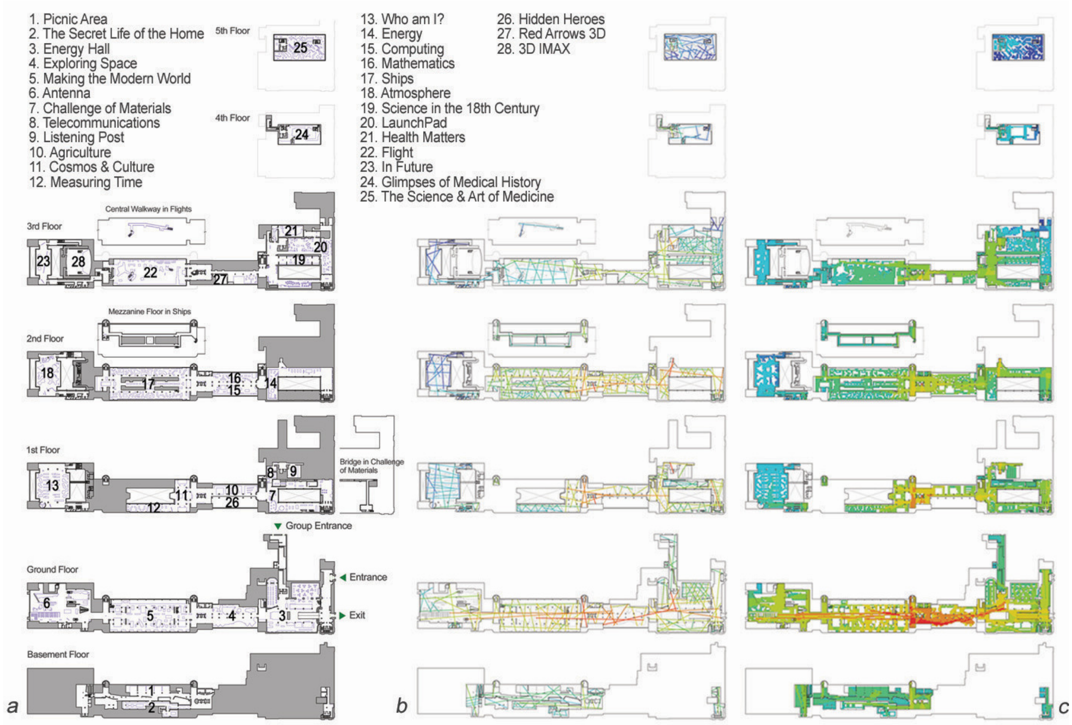
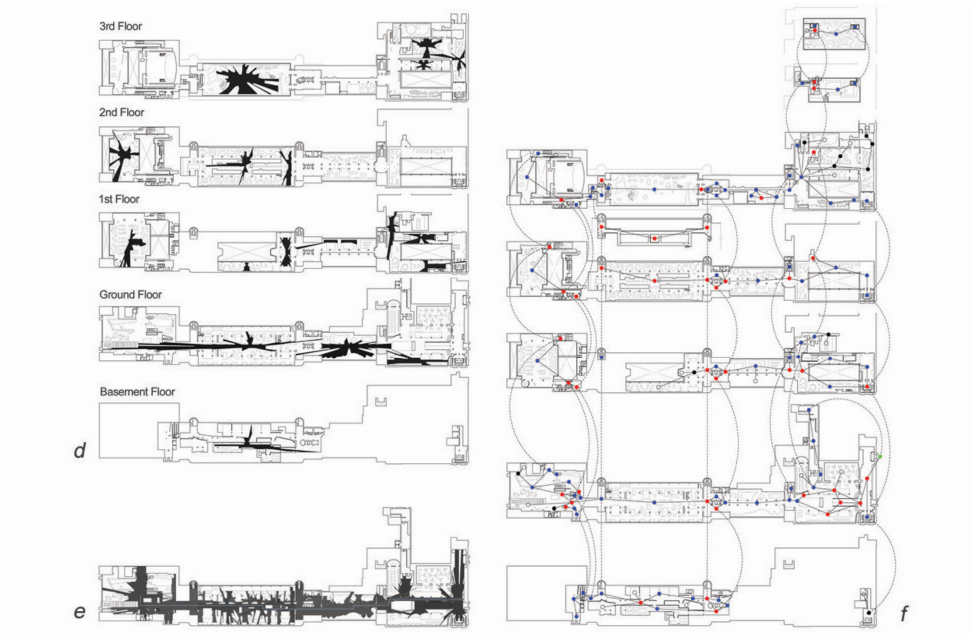


Figure 5: Present layout of the SM in 2011 (a: floor plans; b: axial line graph with integration values (r:n); c: visual integration)



- Intelligibility (r-squared value of correlation between visual connectivity and integration): 0.230
- Space type analysis: ratio of c-/d-spaces: 1.82; c-sequenceL(M): 5.12; c-sequenceD(M): 2.92; d-ring(M): 2.41
- Space type analysis: black circle represents a-space; black solid b-space; blue solid c-space; red solid d-space

Figure 5 (continued): (d: isovists from selected galleries; e: line isovist; f: space type analysis)

From the map of the SM (figure 6), five crucial properties were discovered. 1) Two types of symbols are used: *standard* ones, referring to ancillary facilities or vertical access points with accessible floors; and *discourse* symbols, describing exhibitions. However, when we look at the discourse ones again, they can be categorised into two groups according to different types of exhibitions: the first represents permanent galleries by using numbers only (e.g., '1', '2', or '3'); and the other refers temporary exhibitions in a mixed form of a letter and a number (e.g., 'T1' or 'T5'). However, they do not speak of any disciplinary or architectural meaning, such as hierarchical relations among exhibitions, tectonic ideas with different floors, or circulation systems. 2) It is hard to derive configurational figures from the map (e.g., relations between galleries, back and front of house, or layout of objects) because of open plan layout, which provides nothing but the overall shape of each floor plan. However, it provides us the idea of the direct access to every space and the non-hierarchical relationship amongst exhibitions. 3) Colours, allocated to the floors and discourse symbols, do not explain the architectural characteristics (i.e., material, structural, or historical distinctiveness of EB, CB, WW and 'Infill Project' for 'Wellcome Museum' in the EB, or the peculiar circulation system in WW), nor do they provide the key underlying curatorial intent (i.e., the dialectic between the CB for the past and WW for the present and the future). 4) However, the floor plans are organised in a logical and systematic way in that the basement floor is placed at the bottom of the map, while the upper most levels are located at the top. This strategy, stratifying the floor plans in a vertical way, acts as a presentational code, and it helps us learn efficiently tectonic relations amongst the floors. 5) Coming to the other page of the map, it is mainly devoted to explain a number of exhibitions, laid out in the same way as the diagrams, with brief descriptions with representative images, or general information about hands-on galleries and temporary galleries.

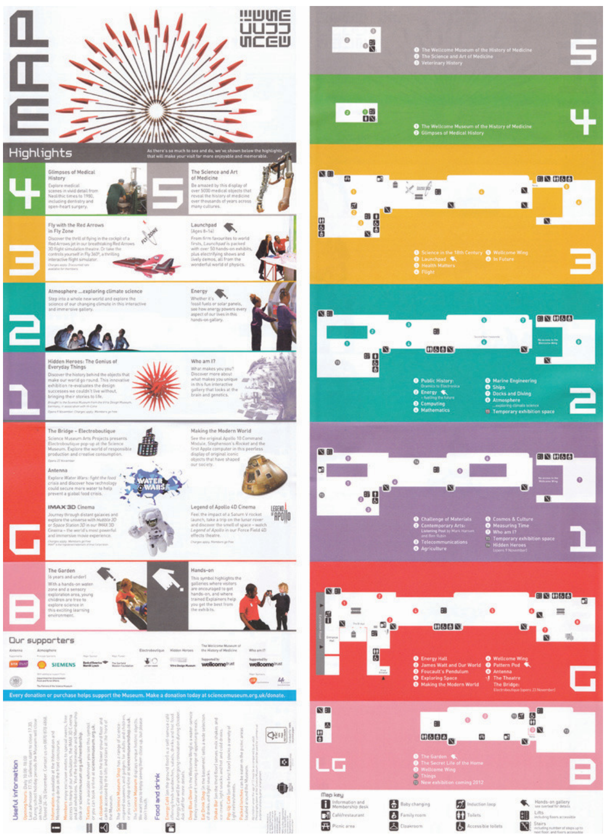


Figure 6: Floor plan map of the SM (left: the front page; right: the rear one, published in Aug. 2011)

From the analytical studies, we can argue that the graphic properties are strongly associated with curatorial intents: in the NH, the map speaks of entertainment, biology, preservation techniques, individuated circulation systems, and walking sequences with highlights (but not sacred space) by a means of discourse symbols, linear perspective, inset images, colour zones, narratives, and detailed descriptions; and in the SM, it claims the potential of objects, non-hierarchical relationships, and thematic or topological frames through open plan layout and non-characteristic discourse symbols, but it fails to deliver the dialectic idea of the collections.

5. Demographic features from survey

To look into to what degree graphic properties would affect visitors' behaviours, survey and movement traces were performed in 2011~2012 academic year. About 100 visitors in each museum were asked to agree to take part in a survey, comprised of gender, age, group size or types, familiarity, and motivations. After having answered, they were unobtrusively followed for the first twenty minutes by other experimenters, who had not participated in the survey, without being informed that they were being observed to avoid intentional behaviours. Their routes were recorded on the blank sheet of plan, and also activities were marked along the paths, such as full stops for studying objects or reading labels, *stops for engagements*, and locations of interacting with maps, *graphic interaction* ("GI"), or having a conversation with staff, *consultant interaction* ("CI"). Table 1 shows the quantitative profile of visitors' demographics from the survey. Regarding familiarity, 36% and 40% of subjects in the NH-Total and SM claimed to have made 4~5 visits before on average, while over 60% were novices ("Ns"). Interestingly, the experienced people ("Es") who used the main entrance in the NH ("NH-Main") have visited more frequently than those who came through the Earth Gallery ("NH-Earth"), 7.8 and 3.6 times respectively.

	NH-Total	*NH-Main*	*NH-Earth*	*SM*
Total no. of subjects questioned & tracked	100	50	50	95
Mean no. of previous visits (experienced only)	5.7	7.8	3.6	4.7
Total no. of experienced visitors	36(.36)*	16(.32)	20(.40)	38(.40)
Total no. of motivated experienced people	25(.69)	11(.68)	14(.70)	21(.55)
Total no. of non-motivated experienced	11(.31)	5(.32)	6(.30)	17(.45)
Total no. of novices	64(.64)	34(.68)	30(.60)	57(.60)
Total no. of motivated novices	21(.32)	10(.29)	11(.36)	12(.21)
Total no. of non-motivated novices	43(.68)	24(.71)	19(.64)	45(.79)
Total no. of motivated subjects in the *NH*	46	21	25	
Dinosaurs	27(.58)	12(.57)	15(.60)	
Human Biology	3(.06)	2(.09)	1(.04)	
Earth Gallery	3(.06)	1(.05)	2(.08)	
Special Exhibitions (Wild-life/Scott's Expeditions)	11(.24)	4(.19)	7(.28)	
Etc. (Dippy/Skeletons)	2(.04)	2(.09)	0(.00)	
Total no. of motivated subjects in the *SM*				33
Interactive Galley (LaunchPad/Garden/Things)				12(.36)
Space & Industry (Exploring Space/Energy Hall/ Making the Modern World/Measuring Time)				7(.21)
Medicine (Health Matter/Wellcome Museum)				3(.09)
Aviations (Flight)				1(.03)
Climate (Atmosphere)				1(.03)
Special Exhibitions (Hidden Heroe/ Robotville)				6(.18)
Etc. (Shop/3D-IMAX)				3(.09)

* Numbers in the parenthesis mean ratios.

Table 1: Quantitative profile of subjects' demographics in two museums

Regarding motivations, there are remarkable differentiations between the two groups, and between the two museums: obviously, the Es in both museums preferred to have their own objectives more than the Ns: and secondly, a greater number of subjects in the NH-Total regardless of their familiarity (46% of the total number) seem to have taken a decision what to see on current visits that that in the SM (34%). Specifically, 58% of the motivated subjects in the NH-Total visited the NH because of ‘Dinosaurs’; eleven came for one of the special exhibitions; six for either ‘Human Biology’ or the Earth Gallery; and the others ‘Diplodocus’ or skeletons of extinct species. In the SM, a third of the motivated subjects came to have a fun with their children in one of interactive galleries (e.g., ‘LaunchPad’, ‘Garden’, or ‘Things’); seven of them to see the collections relating Space or Industrialisation; six for one of the special exhibitions; two for aviations in ‘Flight’ or climate issues in ‘Atmosphere’; and the others for facilities like shop or 3D-IMAX. It is clear that ‘Dinosaurs’, interactive galleries, and special exhibitions in both museums act as key motivations.

6. Analysing movement patterns by using string-matching technique

‘String-matching technique’ (Conroy 2001) was used to analyse visitors’ movement data. Its main objective is to define distinct movement patterns at first by looking at similarity or idiosyncrasy of a path by comparing to all other paths in the sample, and then to demonstrate to what degree these distinctive patterns might be related to variables, such as demographic factors, activities, and graphic or consultant interactions. Each route was converted into a string, which consists of a series of ASCII characters representing convex spaces in this study (figure 7); and its own MNLD value, *‘the mean, normalised Levenshtein distance’*, was calculated by comparing to every other strings using a ‘string-matching algorithm’. Each path was converted again into a *simplified string*, constituted of three categories only (e.g., exhibitions, common spaces, and facilities) to examine how many different stories might be generated in each band. A correlation coefficient analysis by using R was performed.

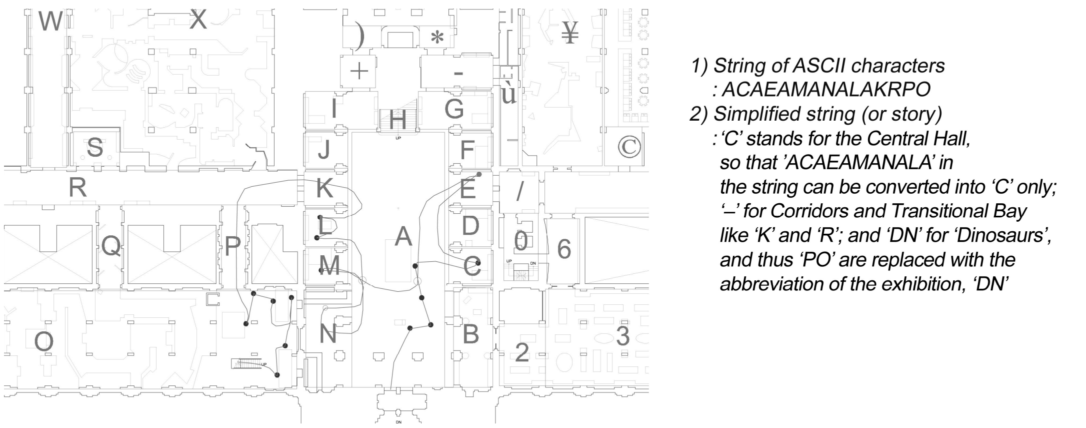


Figure 7: Example of a path drawn on convex spaces with ASCII characters in the NH

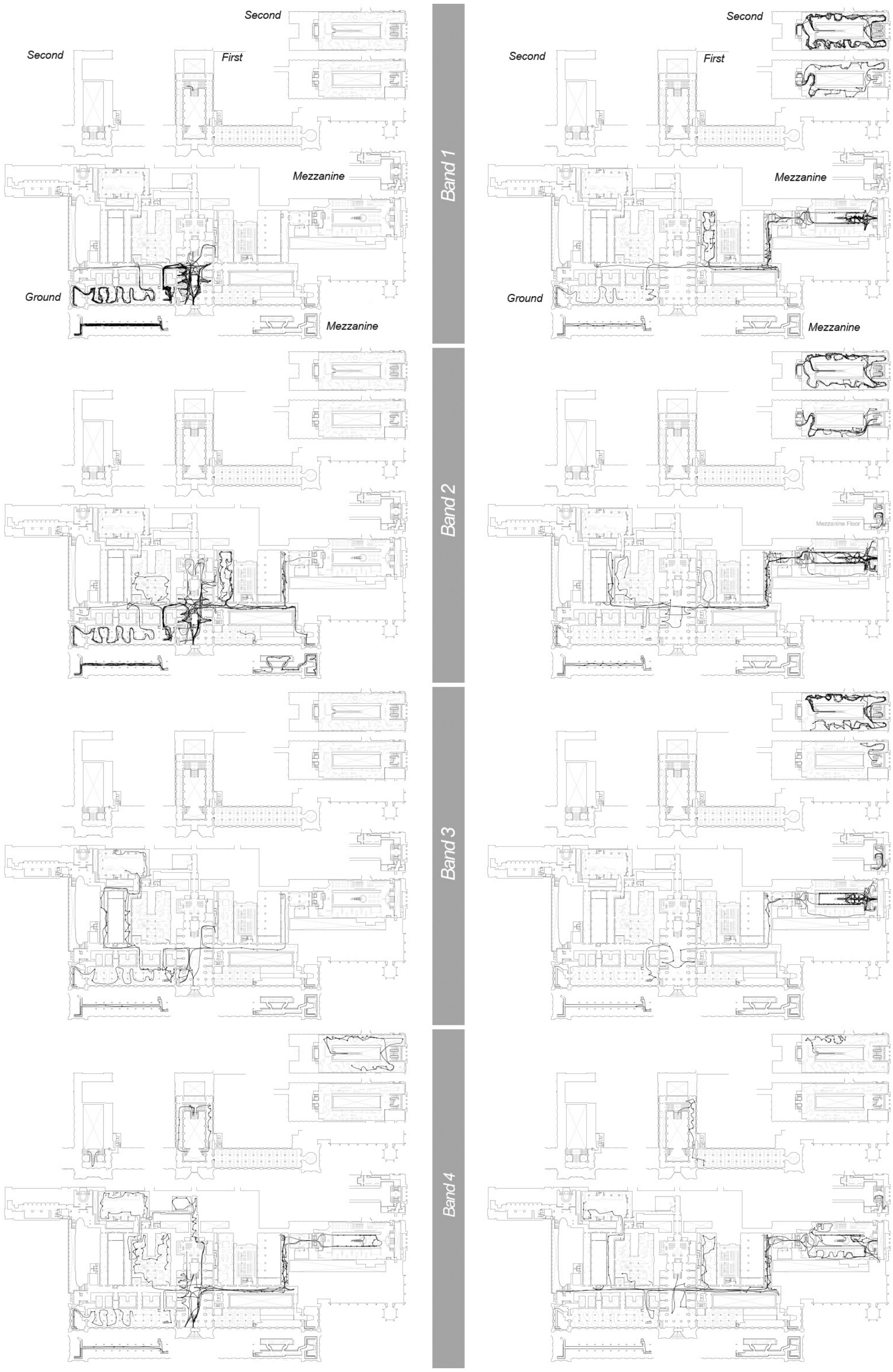


Figure 8: Left column: four bands of the traces in the NH-Main based on the MNLD values in the NH (exc. band-5); right column: four bands in the NH-Earth (exc. band-5~7)

	Band-1	*Band-2*	*Band-3*	*Band-4*	*Band-5*
Mean MNLD value	0.761	0.933	1.000	1.143	1.354
Mean total convex spaces covered	9.6	11.6	15.3	15.6	35.5
Mean total gallery spaces covered	2.3	3.2	5.6	6.4	9.5
Mean total gallery spaces covered (exc. repeated)	1.0	1.7	3.6	3.6	6.0
Total no. of simplified strings or stories	1(.05)*	9(.56)	2(.67)	7(.78)	2(1.0)
Total no. of subjects	20	16	3	9	2
Total no. of Es	4(.25)	6(.38)	1(.06)	4(.25)	1(.06)
Total no. of mEs	4(.37)	3(.27)	0(.00)	3(.27)	1(.09)
Total no. of n-mEs	0(.00)	3(.60)	1(.20)	1(.20)	0(.00)
Total no. of Ns	16(.47)	10(.29)	2(.06)	5(.15)	1(.03)
Total no. of mNs	1(.10)	5(.50)	2(.20)	2(.20)	0(.00)
Total no. of n-mNs	15(.63)	5(.21)	0(.00)	3(.12)	1(.04)
Total no. of motivated subjects	5(.23)	8(.38)	2(.10)	5(.23)	1(.05)
Total no. of non-motivated subjects	15(.52)	8(.28)	1(.03)	4(.14)	1(.03)
Motivations: Dinosaurs	5	5	1	1	0
Human Biology	0	1	0	1	0
Earth Gallery	0	0	0	1	0
Special Exhibitions	0	1	1	2	0
Mean Stops for engagements	20.1	15.4	10.6	23.1	12.0
Mean GIs	1.5	0.7	1.3	0.8	0.0
Mean CIs	0.1	0.1	0.6	0.2	0.0
Mean distance covered	295.2	294.8	421.6	322.0	513.0

* Numbers in the parenthesis represent ratio.

Table 2: Quantitative profile of bands in the NH-Main

	Band-1	*Band-2*	*Band-3*	*Band-4*	*Band-5*	*Band-6*	*Band-7*
Mean MNLD value	0.790	0.847	0.907	0.970	1.048	1.090	1.174
Mean total convex spaces covered	15.3	19.4	14.5	23.0	7.0	34.0	40.0
Mean total gallery spaces covered	4.7	5.1	3.5	7.0	1.0	9.0	10.0
Mean total gallery spaces covered (exc. repeated)	3.5	3.5	2.3	4.8	0.0	7.0	6.0
Total no. of simplified strings or stories	10(.71)*	11(.73)	6(.50)	6(1.0)	1(1.0)	1(1.0)	1(1.0)
Total no. of subjects	14	15	12	6	1	1	1
Total no. of Es	5(.25)	6(.30)	4(.20)	3(.15)	0(.00)	1(.05)	1(.05)
Total no. of mEs	3(.21)	4(.29)	2(.14)	3(.21)	0(.00)	1(.07)	1(.07)
Total no. of n-mEs	2(.33)	2(.33)	2(.33)	0(.00)	0(.00)	0(.00)	0(.00)
Total no. of Ns	9(.30)	9(.30)	8(.27)	3(.10)	1(.03)	0(.00)	0(.00)
Total no. of mNs	2(.18)	5(.46)	2(.18)	1(.09)	1(.09)	0(.00)	0(.00)
Total no. of n-mNs	7(.37)	4(.21)	6(.32)	2(.10)	0(.00)	0(.00)	0(.00)
Total no. of motivated subjects	5(.20)	9(.36)	4(.16)	4(.16)	1(.04)	1(.04)	1(.04)
Total no. of non-motivated subjects	9(.36)	6(.24)	8(.32)	2(.08)	0(.00)	0(.00)	0(.00)
Motivations: Dinosaurs	3	5	3	1	1	1	1
Human Biology	0	0	0	1	0	0	0
Earth Gallery	0	1	0	1	0	0	0
Special Exhibitions	2	3	1	1	0	0	0
Mean Stops for engagements	26.4	17.2	23.5	21.3	1.0	12.0	2.0
Mean GIs	1.7	0.9	0.5	1.0	1.0	0.0	1.0
Mean CIs	0.1	0.2	0.1	0.0	0.0	0.0	0.0
Mean distance covered	393.0	368.8	298.1	432.8	85.0	555.0	540.0

* Numbers in the parenthesis represent ratio.

Table 3: Quantitative profile of bands in the NH-Earth

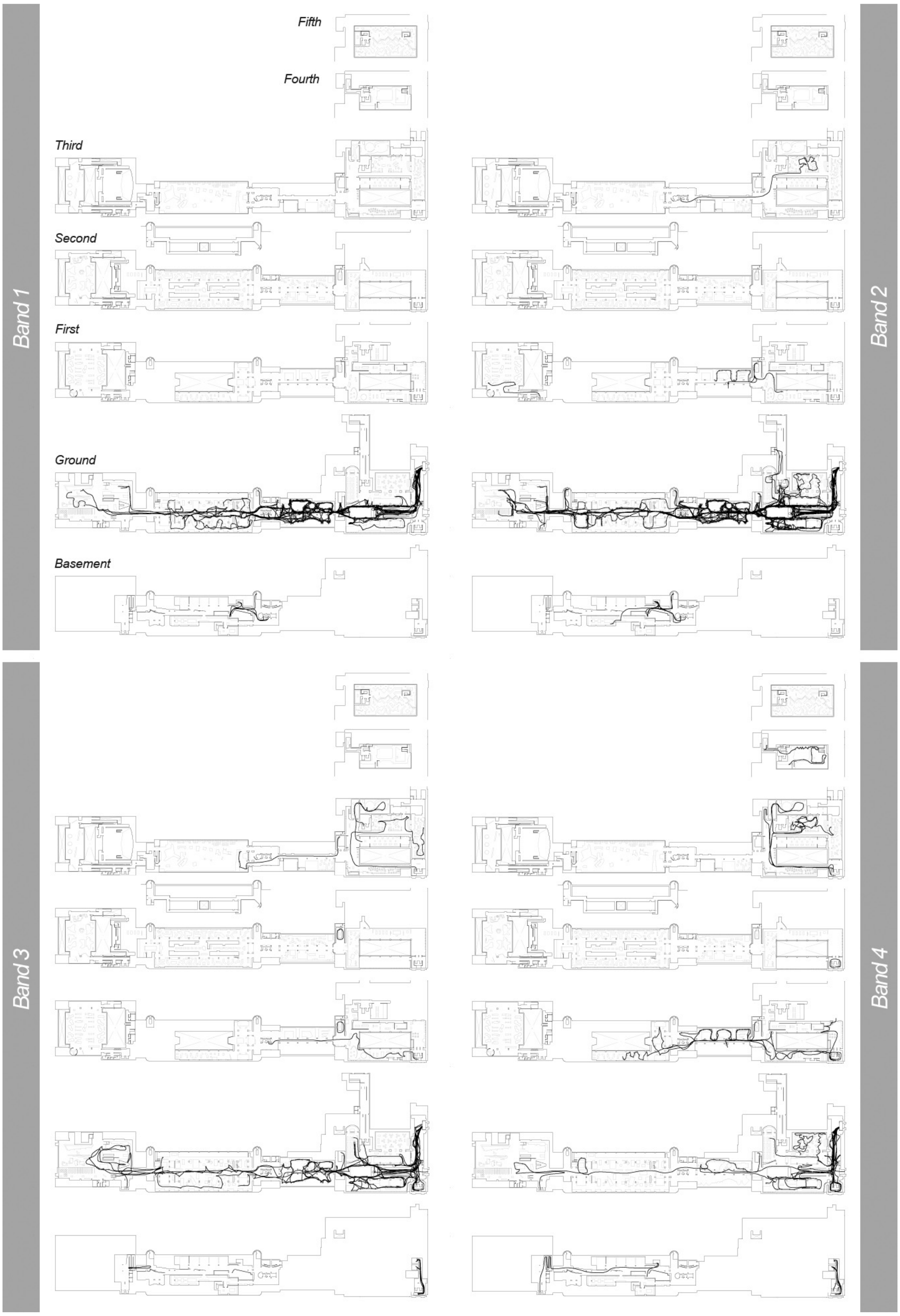


Figure 9: Four bands of the traces based on the MNLD values in the SM (exc. band-5)

	Band-1	*Band-2*	*Band-3*	*Band-4*	*Band-5*
Mean MNLD value	0.729	0.832	0.951	1.076	1.210
Mean total convex spaces covered	13.0	14.6	14.0	10.5	3.5
Mean total gallery spaces covered	3.0	3.1	2.6	2.0	1.0
Mean total gallery spaces covered (exc. repeated)	3.0	2.7	2.3	1.9	1.0
Total no. of simplified strings or stories	5(.19)*	12(.36)	10(.62)	11(.61)	1(.50)
Total no. of subjects	26	33	16	18	2
Total no. of Es	9(.23)	14(.37)	6(.16)	9(.24)	0(.00)
Total no. of mEs	5(.24)	7(.33)	2(.10)	7(.33)	0(.00)
Total no. of n-mEs	4(.23)	7(.41)	4(.23)	2(.12)	0(.00)
Total no. of Ns	17(.30)	19(.33)	10(.17)	9(.16)	2(.04)
Total no. of mNs	2(.17)	4(.33)	3(.25)	2(.17)	1(.08)
Total no. of n-mNs	15(.33)	15(.33)	7(.16)	7(.16)	1(.02)
Total no. of motivated subjects	7(.21)	11(.34)	5(.15)	9(.27)	1(.03)
Total no. of non-motivated subjects	19(.31)	22(.35)	11(.18)	9(.14)	1(.02)
Motivations: Interactive Galleries	4	4	1	3	0
Space & Industry	1	3	1	2	0
Medicine	0	1	1	1	0
Aviations	1	0	0	0	0
Climate	1	0	0	0	0
Special Exhibitions	0	1	2	3	0
Mean Stops for engagements	15.3	13.3	10.3	8.2	5.0
Mean GIs	1.8	2.0	2.1	2.1	1.5
Mean CIs	0.1	0.2	0.2	0.2	0.0
Mean distance covered	246.5	276.1	265.9	215.2	123.9

* Numbers in the parenthesis represent ratio.

Table 4: Quantitative profile of bands in the SM

	Correlation (r^2-value) with *Mean MNLD Value*			Correlation (r^2-value) with *Ratio of Differentiation of simplified strings*		
	NH-Main	NH-Earth	SM	NH-Main	NH-Earth	SM
Mean total convex spaces covered	0.855	0.357	(-)0.374			
Mean total gallery spaces covered	0.879	0.246	(-)0.851			
Mean total gallery spaces covered (exc. repeated)	0.803	0.135	(-)0.999			
Ratio of differentiation of simplified strings (or stories)	0.904	0.174	0.870			
Ratio of Es	*(-)0.031	(-)0.655	(-)0.079	(-)0.034	(-)0.142	(-)0.169
Ratio of mEs	(-)0.166	(-)0.100	0.003	(-)0.330	0.181	0.064
Ratio of n-mEs	0.059	(-)0.619	(-)0.337	0.207	(-)0.742	(-)0.198
Ratio of Ns	(-)0.692	(-)0.736	(-)0.746	(-)0.816	(-)0.605	(-)0.782
Ratio of mNs	0.021	(-)0.208	(-)0.031	0.128	(-)0.065	0.001
Ratio of n-mNs	(-)0.691	(-)0.569	(-)0.805	(-)0.901	(-)0.636	(-)0.888
Ratio of motivated subjects	(-)0.031	(-)0.197	(-)0.001	(-)0.034	(-)0.001	0.052
Ratio of non-motivated subjects	(-)0.689	(-)0.637	(-)0.780	(-)0.838	(-)0.710	(-)0.740
Mean Stops for engagements	0.011	(-)0.080	(-)0.994	(-)0.028	(-)0.070	(-)0.911
Mean GIs	(-)0.386	(-)0.412	0.628	(-)0.463	0.105	0.850
Mean CIs	0.126	(-)0.682	0.553	0.221	(-)0.196	0.835
Mean distance covered	0.124	0.016	(-)0.289	0.209	0.897	(-)0.065

* '(-)' means that there is a negative correlation between the two variables.

Table 5: Correlation coefficients of mean MNLD values and simplified strings to other variables

Figure 8 and table 2~3 show movement patterns and quantitative profiles according to the MNLD values and different entry points in the NH. In the NH-Main, the most popular route in the sample was the one that led directly to 'Dinosaurs' from the Central Hall: 37% of motivated experienced subjects ("mEs") and 63% of non-motivated novices ("n-mNs") took this route with the greatest number of GIs (1.5). Surprisingly, they experienced exactly the same itineraries: they dispersed in the Central Hall to look at objects in the bays, and then they headed to the west wing with the GIs at one of the transitional bays. Thus, it can be said that the intuitive discourse symbol of 'Dinosaurs' conserves the structured movement pattern (or redundant exploration) even though three quarters of them are non-motivated visitors. Moving on to the other bands, however, we can see that routes became dispersed across the plan, and a number of distinctive stories were created. For example, the band-2 shows that subjects evenly headed to one of wings, and they created nine different stories to see either 'Human Biology', 'Mammals', 'Creepy Crawlies', 'Birds', 'Ecology', or 'Last Impression'; even one of them reached to a lift in the orange zone to go up to 'Cocoon'. In the band-3 and 4, subjects moved even further to visit the very peripheral galleries like 'Blue Whale' and 'Marine Invertebrates', or they started to go up to the upper floors to see 'Giant Sequoia' or 'The Power Within' in the Earth Gallery.

However, the MNLD values in the NH-Earth give an opposite result. In the band-1, it is hard to distinguish which route might be the most popular one because of two main streams: one leads to the upper level of the Earth Gallery via the escalator; and the other is the one that guides to the rest of the museum (i.e., the Waterhouse' building) through the Earth Hall, 'Last Impression', and 'Birds'. In the band-2, these two quite different but strongly framed routes were discovered as well. Thus, two bands show the similar results of gallery spaces, simplified stories, and distributions of subjects. The only difference between them is the activities, such as the number of engagements (26.4 and 17.2 stops for the band-1 and band-2 respectively) and GIs (1.7 and 0.9). It means that the subjects in the band-1 actively interacted with the map and exhaustively engaged with objects during their journeys, while the people in the band-2 examined not everything but selectively. However, when we see the result of the band-3 it is quite surprising because it shows the least number of GIs (0.5), the least walking distance (298), and the slowest speed (0.29 m/s) excluding the last three bands (band-5, 6, and 7). More interestingly, they took very similar itineraries.

In the SM (figure 9 and table 4), the most favourite routes (band-1) are the ones that lead to 'Antenna' from 'Energy Hall' through 'Exploring Space' and 'Making the Modern World', with the greatest number of stops (about 15). Interestingly, the subjects in this band, except for four of them who went down to one of interactive galleries on the basement floor, preferred to explore not in a dispersed but in a strongly linear way, so that their movement patterns were closely incorporated with the main axis. As a result, they created only five different stories. When we move on to the next bands, it is clear that as the number of the simplified strings was increased, the movement patterns became dispersed across the building: for example, the subjects in the band-2 actively engaged with exhibits in the peripheral spaces in 'Energy Hall', and even they entered into one of ancillary facilities. In the band-3 and 4, however, we can see distinctive patterns, compared with the former ones: the subjects in the band-3 did not stop exhaustively but selectively, and they kept moving along the integration core; whereas, the subjects in the band-4 preferred to move not in a horizontal way but in a vertical way. In other words, their movement patterns were associated with not the configurational properties, but their motivations because they moved at first to the floor on which their destinations would be placed.

To what extent do these results (i.e., the similarity of routes and the differentiation of stories) relate to demographic factors, behaviours, or interactions? Is there any significant correlation among them according to different entry points, distinct configurational features, and graphic styles? Table 5 represents the statistical results of the correlation between mean MLND values, ratio of generating distinct stories in bands, and the variables. Note that the most idiosyncratic routes (i.e., band-5 in the NH-Main, band-5/6/7 in the NH-Earth, and band-5 in the SM) were excluded in the correlation coefficient analysis to get a reasonable result. Except for the NH-Earth, it is obvious that there are strong correlations between the mean MNLD values, the mean number of gallery spaces, and the ratio of the simplified strings: in the NH-Main, as the visitors disperse across the building (i.e., taking idiosyncratic routes), they create their own stories (r-squared values: 0.879, 0.803, and 0.904 for galleries including repeatedly visited galleries, galleries excluding the repetitions, and simplified strings). Likewise, the visitors in the SM show the similar results, but they are negatively correlated with the popularity (-0.851 and -0.999 for galleries including and excluding repetitions). It means that as they take more popular routes, they visit a greater number of exhibitions; while as they move dissimilarly, they traverse a lower number of gallery spaces. When we think of this tendency with the ratio of the differentiation of the stories, it is quite surprising that the subjects who build up their own routes challenge to minimise to visit galleries (0.870 for the simplified strings), in other words, they would like to plan carefully what to see and how to get to destinations.

Regarding familiarity, there is a strong tendency between MNLD values and Ns (-0.692, -0.736, and -0.746 for the NH-Main, NH-Earth, and SM respectively), and particularly n-mNs are strongly correlated with the popularity of routes (-0.691, -0.569, and -0.805). It means that most n-mNs, except for those in the NH-Earth who move around distinctively, prefer not to challenge to create their own routes, but rather they explore in a more or less structured way: for example, the most popular route in the NH-Main strongly reflects the attraction, 'Dinosaurs'; while that in the SM is dramatically incorporated with the integration core. Likewise, there is a strong correlation between ratio of simplified strings and Ns (-0.816, -0.605, and -0.782), and this negative correlation becomes stronger between the simplified strings and n-mNs (-0.901, -0.636, and -0.888). On the contrary, the movement patterns performed by Es, except for the n-mEs in the NH-Earth, are not characterised by such attractions or spatial configurations because of the weak correlations with the simplified strings (-0.034, -0.142, and -0.169 for the Es), but rather they take new itineraries and experiences. This dialectic between the Ns and Es indicates that the Es generate something new experience through the distinctive routes, while the n-mNs' movement tends to be uniformed. However, when we look at the correlation between mNs, MNLD values and simplified stories, they seem to produce their own itineraries (correlation with MNLD values: 0.021, -0.208, and -0.031; that with the simplified strings: 0.128, -0.065, and 0.001). These opposite result from the mNs and n-mNs indicate that motivations characterise their movement patterns in a certain way.

Move on to the correlation between MNLD values, simplified strings, and interactions. In the SM, it is obvious that the routes and stories are strongly correlated with the GIs and CIs (0.628 and 0.553 for the mean MNLD values; 0.850 and 0.835 for the stories), meaning that as the routes become idiosyncratic, the GIs and CIs affect their movements and itineraries; whereas, as the interactions take place less, the subjects take the popular routes. However, we should be aware that the dissimilar routes in the SM are significantly correlated to the CIs, meant that the map of the SM fails to deliver spatial information (i.e., procedural knowledge) to the motivated subjects, so that they have to have a brief conversation with staff to find out how to get to destinations. On the other hand, the interactions in the NH are not correlated with routes or stories. However, when we look carefully at the statistical result again, there is a meaningful result of the correlation between the MNLD values and the stories according to the entry points: firstly, for the subjects in the NH-Main, there is no significant relation between the MNLD values and the GIs (-0.386) or CIs (0.126), but the stories are meaningfully correlated with the GIs (-0.463). It means that they prefer to use positional information about exhibitions (i.e., attractive galleries) rather than procedural (or route) knowledge. For the subjects in the NH-Earth, in contrast, the MNLD values are correlated with the GIs (-0.412) and CIs (-0.682), rather than the stories (GIs: 0.105 and CIs: -0.196), meaning that unlike those in the NH-Main, they actively interact with the map to get topographic information (e.g., the way to get out of the Earth Gallery, detailed routes to 'Dinosaurs', or special exhibitions from the Earth Hall). If we go further, it might be said that the interactions are closely related to the configurational features (i.e., intelligibility) and the graphic properties (i.e., distinct types of spatial knowledge like topological or topographical information): for instance, in the unpredictable layout (e.g., the NH-Earth and the SM) with the map focused on topological knowledge (e.g., the map of the SM), visitors actively look for route knowledge; while in easily understandable layout (e.g., the NH-Main) with the map representing topographic knowledge (e.g., the map of the NH), they prefer to use survey knowledge.

7. Conclusion

As aforementioned, museum layout is strongly linked to movement patterns, social encounters, and pedagogic implications. The main contribution of this research to museum studies is to suggest a reflective relation of museum maps to curatorial intents (or underlying pedagogic propositions); to develop a methodology to understand visitors' behaviours through a series of studies, from historical review, space syntax analysis, survey questionnaire, movement traces, and to applying string-matching technique; and to find a significant correlation between maps and museum experiences. From investigating museum maps by using ten codes, they can be understood as focusing devices for *embodying* curatorial intents by using distinctive graphic styles, with the aims not only to deliver spatial knowledge but also to make underlying disciplinary knowledge visible. However, it should be noted that maps do not always reflect current curatorial intentions. Sometimes it combines old-fashioned ideas to make it easy to communicate with readers, or it does not represent all significant curatorial implications.

By analysing data of subjects interviewed and individually tracked for the first twenty minutes in both museums, we found that there are fundamental differences according to demographic factors, graphic styles, and configurational features. Experienced subjects actively interact with maps either to find out the way to destinations or to take a decision what to see on current visit, so that they tend to create their own itineraries throughout their journey, irrespective of intelligibility or graphic styles. It is also surprising that they move at first to the floor on which their destination would be placed. In contrast, when non-motivated novices are in a predictable environment and given a map mainly concerned with topographic properties, they instantly respond to graphic properties, particularly to attractive elements like amused and exciting intuitive discourse symbols. When they are in an unintelligible layout and provided a map focused on topological information only, their movement patterns are strongly associated not with the graphic properties, but with layout of space or exhibit. If we go further with these findings, it can be argued that visitors create new stories or overcome pre-defined meanings through active interactions with route knowledge, and thus we say that maps work in a generative way; on the other hand, maps regulate exploration or guide framed spatial structure through graphic propositions based on survey knowledge, and therefore they work in a conservative way.

As we focus on the impact of museum maps on our spatial experiences, these distinctive results become fundamental. This study provides an in-depth understanding of visitors' explorations as we develop methods of profiling them according to demographic and behavioural factors. Also, it shows that the string-matching technique helps us identify critical differentiations among their movement patterns, and it is used as a framework to investigate the relations between behaviours, configurational features, and graphic properties.

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