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The dynamics and diversity of space use in the British Library

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Abstract

The Space Syntax study of buildings typically distinguishes between weak and strong programming, where social behaviours either follow or defy the spatial logic of a building. This is often based on analysing collective and aggregate patterns of behaviour. This paper builds on recent work redefining our understanding of weak and strong programming, yet aims to analyse usage patterns and spatial affordances in a much more fine-grained way by taking diversity of user groups as well as the temporal unfolding of behaviours into account. The British Library acts as a case study and is investigated based on a rich empirical dataset of observed user behaviours.

Results suggest that the British Library shows both strong and weak programming: movement flows only partially followed spatial configuration, and the interface the building constructed kept people apart rather than bringing them together. In addition, large variations in user activities existed in some parts of the Library, all of which points towards strong programming. At the same time however, certain activities showed clear spatial preferences and significant differences in local and global visibility patterns, which illustrates weak programming. It was also shown how dynamic and diverse user behaviours emerged in the British Library, highlighting the need to draw a nuanced picture of usage. The contribution of the paper thus lies in a detailed and deep analysis of usage patterns, unpacking variations in behaviours between different users at different times and linking this both to the affordances of configuration as well as programmatic influences.

Keywords

Public libraries, Space syntax, Space usage, Temporal dynamics, Strong and weak programming.

1. Introduction: More than just books…

Buildings are dynamic settings that accommodate a range of different uses. A hospital for instance is not just a place for curing the ill, but also a workplace for nurses, doctors, cleaners and porters (see for instance Heo, Choudhary, Bafna, Hendrich, & Chow, 2009 on nurses assignments and behavioural patterns). A school not only enables teaching and learning, but is also an important place for socialisation, making friends and hanging out (Minuchin & Shapiro, 1983; Sailer, 2015). Shops have clear social functions beyond their retail purpose (Koch, 2014). Museums do not only exhibit pieces of art, but also educate, entertain and sell merchandise (Kwon & Sailer, 2015). Likewise, libraries have always been meeting places for communities in addition to storing books and organising access to information (Capille & Psarra, 2015).

All of the above descriptions centre on what people do in buildings. Indeed, most buildings are defined by functions or so called 'use types' (Forty, 2000) or 'activity types' (Steadman, 2014): a hospital is a hospital because of what happens there, and likewise a school is a school again because of what goes on inside it (Hillier, Hanson, & Peponis, 1984).

Yet, it seems that what people do in buildings becomes even more important, as a new focus on the human side of architecture as well as on people's experiences, behaviours and usage patterns can be observed in recent discourses. The question of usage and daily life has already been popular in the 1970's with architects like Herman Hertzberger defining architecture as concerned with 'daily life lived by all people' (Hertzberger, 1991), however only recently, scholars have argued that the social agenda of architecture has too long been a blind spot that needs re-addressing (Cupers, 2013). Other recent publications on usage and the social role of architecture and design (Awan, Schneider, & Till, 2011; Bergdoll, 2010; Maudlin & Vellinga, 2014; Till, 2009) underlined the important reading of buildings as 'lived in' (Brand, 1994; Hollis, 2009).

If we consider buildings based on usage, change becomes essential. Public libraries, like most other building types have seen a dramatic change in how they are used, perceived and experienced. The increasing digitisation of content means that new ways of accessing collections emerge, thus shifting the necessity of a physical site away from providing access and towards other uses. Drawing on a study of 24 recently built monumental public library buildings, Shoham and Yablonka (2008) came to the conclusion that the new-built libraries had increased user numbers, were full of life and served wider purposes as symbols of culture, as tourist attractions, but also as pleasant meeting places in a quiet cultured environment.

The British Library forms a particularly interesting case in this context. The architect of the British Library, Sir Colin St John Wilson (1998) described the multitude of functions to be accommodated as: a day-to-day workplace, an institution that embodies and celebrates national memory, a storage of collections, places of study, exhibitions of its treasures, an event-space hosting lectures and seminars, and back-of-house functions such as conservation laboratories and administration. This already points to a real diversity of space usage patterns. How the publicly accessible areas of the Library are indeed used in their everyday functioning will be explored in this paper, drawing on a rich data set of empirical and both quantitative and qualitative participant observations, collected in 2009 and 2010 by MSc students at the Bartlett, UCL. It will be asked how people move around in the building, to which degree the spatial layout (analysed with Space Syntax) informs usage patterns and how usage varies between different user groups, but also over time. Its main aim is to provide a sketch of the multi-functionality of the building and describe user groups and usage patterns in as much detail and variation as possible. This is an important task, if we want to reflect on how to design 'social' buildings in the future, where usage and people's activities, preferences and experiences are actively anticipated, embedded,

and allowed to grow and change.

This paper is structured as follows: Chapter 2 will provide theoretical foundations for the empirical explorations of usage patterns in the British Library by sketching research on library buildings and human behaviours, but also by elaborating on the Space Syntax theory of 'strong and weak programming' in buildings. Chapter 3 will introduce the British Library as a case study, followed by a detailed description of methodology in Chapter 4. In four consecutive steps, Chapter 5 will discuss the diversity and dynamics of usage patterns in the British Library and a final Chapter 6 will draw conclusions, discuss limitations of the study and provide an outline of future research in the field.

2. Usage patterns and building types: On strong and weak programming

In their paper 'Visible Colleges' Hillier and Penn (1991) conceptualised buildings as either strongly or weakly programmed depending on the degree to which the activity patterns inside the buildings followed strict rules, procedures and models. This theory is crucial in understanding the relationship between spatial layout and usage patterns inside different building types.

A programme was defined as *"not the organisation it houses (…) [but] the spatial dimension of an organisation, and the key element in any programme is the interface, or interfaces, that the building exists to construct (…) [i.e.] the spatial relation between or among two broad categories of persons (…) that every building defines: inhabitants, or those whose social identity as individuals is embedded in the spatial layout and who therefore have some degree of control of space; and visitors, who lack control, whose identities in the building are collective, usually temporary and subordinated to those of the inhabitants"*. (Hillier & Penn, 1991, p. 33)

Therefore, buildings were considered strongly programmed if the interface between user groups was highly controlled and the patterns of encounter followed so called 'long models' with a high degree of prescription and determinism (Hillier & Hanson, 1984). A court was the classic example of a strong programme building, since different user groups with varying degrees of inhabitant or visitor status such as judges, barristers, witnesses, defendants and public were channelled through the building along separated paths so that their movement was highly controlled and encounters were actively hindered until all users met in the highly orchestrated and ritualised court room proceedings (Hanson, 1996). In contrast, buildings were seen as weakly programmed if the interface between user groups was not controlled and everyone could encounter everyone else freely, following 'short models' with a high degree of randomisation and morphogenesis (Hillier & Hanson, 1984). The most used example for traditionally weakly programmed buildings was the editorial floor of a newspaper, which flourished through generative and unstructured encounters among different users.

The implications of this theory for the understanding of buildings and usage patterns lie mainly in the question how closely movement flows and resulting patterns of encounter correspond to spatial configuration. Traditional Space Syntax theory would suggest that movement flows are highest in areas of high spatial integration – so called 'natural movement' (Hillier & Iida, 2005; Hillier, Penn, Hanson, Grajewski, & Xu, 1993), however, adding strong and weak programming, we would only expect this relationship to hold in the case of weak programming, where randomisation is at play and the layout can act morphogenetically. In contrast, it could be argued that movement flows follow programme in strongly programmed buildings.

Over recent years, the theory of strong and weak programming was taken up by different researchers and articulated further, for instance Koch and Steen (2012) proposed a new criterion for strong programming, thus adding more nuance and variation to the original concept. Likewise, Capille and Psarra (2013) suggested that the unequal distribution of activities across different spaces and functional areas of a building meant strong programming, whereas an equal distribution highlighted weak programming.

Studying two public libraries in London, it was concluded that one library was weakening the influence of programme on activities, while the other one was strengthening it.

Additionally, it was shown that elements of strong programming could appear in traditionally considered weakly programmed building types such as workplaces and offices, for instance in the form of attractors that may deflect movement flows away from spatially integrated areas (Sailer, 2007, 2010). Similarly, buildings considered strongly programmed such as hospitals could show aspects of strong and weak programming, even within a single case depending on which criterion was applied (Sailer et al., 2013).

What can be learnt from these studies, is the insight that space usage activities are dynamically enfolding systems, embedded in spatial situations and practices, driven by organisationally defined roles and programmes, but also distributed in space by configuration. Building types (such as hospitals, libraries or offices) cannot be associated with one type of programming per se; neither does a particular building necessarily follow clear categorisations as strong or weak programme. The theory of strong and weak programming of buildings can help scrutinise phenomena, yet detailed analysis is needed before a judgement on the degrees and levels of programming in its interplay with spatial configuration can be made.

For the study of libraries, which in the traditional dichotomised description of either 'strong' or 'weak' would have been seen as a typical example of a weak programme (Zook & Bafna, 2012), this means scrutinising the space for aspects of strong programming (rules, procedures, attractors, strong distribution of activities by function, movement flowing against configurational logic) in addition to understanding weak programming and spatial practices.

Particular studies on libraries within the framework of Space Syntax seem worth mentioning, too.

With the aim to discover how spatial systems produce meaning, Koch (2004) studied three public libraries in Sweden and concluded that three different forms of knowledge representation (tree-like, network-like, as a control system) were found. Overall, it was concluded that contemporary libraries could be seen as systems that increasingly aim to integrate people and promote social encounter rather than keep people apart by providing silence, solitude and concentration. To that end, it was shown that the activity of reading occurred mainly next to heavily used corridors and areas of movement flows, thus giving rise to social encounters.

This very phenomenon of reading in close proximity to highly integrated areas was found in a study of nine academic libraries in Portugal as well, however, here it was reported as a noise problem inhibiting concentration (Both, Heitor, & Medeiros, 2013). Another recent study on two academic libraries in London (Zong, 2015) focused on the diversity of activities as a result of new pedagogic ideas and digital access. Analysing both spatial configuration and furniture arrangements as affordances for usage, it was proposed that a diversity of spatial characteristics allowed for a diversity of usage patterns to unfold.

The theme of libraries changing to accommodate different functions was also the subject of a syntactic study of 18 public libraries in France, where it was investigated how traditional libraries with closed collections and a central catalogue changed into so called 'mediatheques' providing access to a diversity of media sources and information types, which meant a spatial change towards open bookshelves and reading spaces (Lim & Kim, 2009). Results suggested that newer building types which followed the mediatheque model had lower overall values of visibility on average, but also a wider and more diverse range of configurational options.

Visibility relations also feature in the paper by Zook and Bafna (2012), which highlights how everyday activities (borrowing a book, attending a scheduled meeting, meeting a friend in the reading rooms) in the Seattle Public Library – a building with a highly unusual spatial composition – still follow genotypical patterns of visual access, where paths lead through expected levels of openness and enclo-

sure, thus publicness and privacy, underlining the view of the library as a known institution. This so called 'social staging' is contrasted by a view of the 'phenomenal staging' – the subjective, individual experience of a user as they make their way through the building, which is characterised by unexpected vistas, hidden outlooks and surprising elements.

Libraries were also used as settings to understand issues of wayfinding and signage (Carlson, Hölscher, Shipley, & Conroy Dalton, 2010; Li & Klippel, 2010, 2012) and to test new methods for user feedback and Post-Occupancy Evaluations (Dalton, Kuliga, & Hölscher, 2013).

In summary, previous research has shown how libraries have become settings staging a multitude of different usage patterns beyond the traditional access to collections and the accommodation of the process of reading. Instead libraries were shown to be social spaces, experienced differently by people and supported by specific configurational properties of the library buildings.

How these phenomena resonate in the case of the British Library will be explored in the following chapters.

3. Case study: The British Library

This paper draws on rich observations of space usage in one particularly interesting building: the British Library. As National Library of the United Kingdom, its aim is to store every book published in the UK and

Figure 1. *Annotated floor plan of the British Library.*

make its collections freely accessible to the public. With a building size of more than 122,000 sqm it stores around 170 million items (among them almost 14 million books)[1] and employs around 1200 staff in its main St Pancras building. As an institution, the British Library was founded in 1972 by an Act of Parliament, but first continued having its collection and reading rooms housed in the British Museum, until it moved to its own site in 1997, when the first reading room opened.

The British Library's main building in the centre of London near the railway station St Pancras was fully opened to the public in 1998 after a more than thirty-five year-long conception, design and construction process. The British architect Colin St John Wilson created a building 'based on purpose' and human scale in an approach that he called 'the other tradition' of Modernism (Wilson, 2007). For Wilson, architecture was grounded in use, creating an ordered framework for activities to happen; this was also called an 'architecture of experience' (Stonehouse, 2004). The building was described as 'inviting' and 'democratic' by critics:

> "A library might be expected to be conceived as a monument. (…) Yet this building [the British Library] has found a kind of democratic equivalent. (…) This kind of monumentality is not imposed upon us; it is assigned by us. So the building is symbolic, but this symbolism is not assertive and it is not about great occasions or collective events. The building seeks relationships with the individuals who use it and visit it, through a sense of invitation first evident in the forecourt and entrance. You are invited to be a participant, not merely a spectator." (MacCormac, 2004, pp. xii-xiii)

The way in which the building negotiates between individual usage and institutional representation was described as 'intimate monumentality':

> "The building is book-like, revealing its inner world only when entered, an individual, intimate act. The hard, rather sober exterior allows the interior to be revealed and discovered on entering and using the library (…) – all part of an intimate experience of monumentality." (Stonehouse, 2004, p. 69)

It was also praised to provide an "*inherent versatility of form*" (Stonehouse, 2004, p. 79), able to adapt to future usage and organisational needs, for instance the new ways in which information will increasingly be stored and accessed digitally.

4. Methodology

This paper combines the syntactic study of the British Library, based on axial accessibility maps (drawn on knee level) and Visibility Graph Analysis (VGA, constructed on eye level) (Turner, Doxa, O'Sullivan, & Penn, 2001) with detailed and structured observations of space usage patterns. The following three standard Space Syntax observation techniques (Al-Sayed, Turner, Hillier, Iida, & Penn, 2015; Grajewski, 1992) were used: gate-counts, traces by following people and snapshots.

For the gate-counts, movement flows across a total of 127 imaginary gates on all six public floors of the British Library were counted for five minutes each in the morning, midday and afternoon on three days (including Saturday) in 2009 and on two days (including Sunday) in 2010. Gender and readership status[2] was recorded. Data was aggregated across all observations and collective hourly flow at each gate was calculated.

Movement was also captured through traces, where observers picked up building users at entrances or other movement distributors on each floor plate (lift, staircases) and discretely followed them for 10 minutes (in 2009), 5 minutes (in 2010) or until they had reached a destination (for instance a desk in a Reading Room or a seat in the café), or in fact left the floor plate or building. The route they took was traced on a floor plan and digitised in GIS. A total of 679 building users were shadowed during Library opening hours, and additional demographic and user specific information (gender, estimated age range, formal or informal attire, Reader or Non-Reader) was noted.

Snapshots recorded the exact location and type of activity of building users at a precise moment in time. All six publicly accessible floors of the building were observed repeatedly throughout the course of the day. Most areas

[1] *Some of the books of the British Library are stored in its branch in Boston Spa in Yorkshire, from where they can be ordered to the Reading Rooms in St Pancras within 48 hours; basic statistics are from Wilson 1998 and updated statistics on the building are taken from: https://en.wikipedia.org/wiki/British_Library*

[2] *Building users were distinguished by visual cues: Readers could be recognised by their Reader's passes, sometimes worn around people's necks, or more obviously, by carrying their belongings in plastic carrier bags, which were the only bags allowed inside the reading rooms. This means that everyone categorised as a Reader in the observations definitely had a Reader's pass, but the observations could be biased by not recognising all Readers as such (for instance those leaving their possessions in lockers or at a desk in the Reading Rooms and going for a coffee).*

were observed eight times in total with more intensively used areas captured up to 17 times to get a higher data resolution. Primary and secondary activities were recorded: primary activities included sitting, standing and walking as individual behaviours and interactions as group behaviours, while secondary activities distinguished a total of 22 different behaviours (such as searching, shopping, working on a laptop, reading, looking at an exhibition) and combinations of behaviours (such as laptop and reading, looking at an exhibition and talking, etc.). A total of 7993 people were observed.

5. The British Library: Diversity and dynamics of usage patterns

Patterns of usage in the British Library will be analysed in this section, discussing the distribution of activities in space, the diversity of behaviours, rhythms and temporal patterns as well as emerging communities and their specific needs and activities.

5.1. Movement flows

As a first step in the analysis, it is of interest to understand the overall distribution of people in the building and investigate to which degree movement flows are driven by configuration (indicating a weakly programmed building) or in contrast by programme and function (indicating a strongly programmed building).

Four spatial variables of the axial map were analysed regarding their relationship to the overall flow of people in the British Library, as well as to the flow of Readers and Non-Readers (using gate-count data): Connectivity, Integration Radius 3 (Local), Integration Radius N (Global) and Choice. No single relevant correlation was found, although Choice and Global Integration yielded highly significant / significant results for Non-Readers ($p<0.0068^{**}$ and $p<0.0142^{*}$ respectively) yet with very low R^2 values of 0.03 each. Clearly, spatial configuration cannot explain the overall distribution of moving people very well in this case. Interestingly better correlations appear for a floor by floor analysis, particularly for the upper floors and for the non-reader demographic, as shown in Table 1.

It seems that building users do follow the configurational logic of space to some degree when they are moving through the building, yet this is only the case for Non-Readers and only for the 1st, 2nd and 3rd floors, where correlation coefficients higher than 0.20 were achieved. Even then this is not a very strong relationship.

Various factors interfere with the configurational logic. It could be argued that Readers know the building well and come for a particular purpose, i.e. to use the collections and take a seat in one of the Reading Rooms. Therefore, their movements are much more programmed and as such do not follow configuration. Secondly, the ground floor as well as the floors above (mezzanine) and below (lower ground) provide many different facilities and places of interest, most of them specifically targeted at Non-Readers, such as the shop, exhibition spaces, the café and canteen, the information desk, the cloak room, etc. This means attractors (Sailer, 2007) divert the flow of movement of Non-Readers and may counteract configuration as a way to distribute people. The role of the entrance should not be underestimated either. Every single building user pass-

Table 1. *Coefficient R2 for correlation of movement flows (total, Reader, Non-Reader) with global Integration [INT] and Choice [CHOI].*

	TOTAL		READERS		NON-READERS	
Floor	**R^2 [INT]**	**R^2 [CHOI]**	**R^2 [INT]**	**R^2 [CHOI]**	**R^2 [INT]**	**R^2 [CHOI]**
Whole Building	0.00	**0.01****	0.00	0.00	**0.03***	**0.03****
Lower Ground	-0.01	-0.02	-0.07	-0.02	-0.00	-0.00
Ground	0.08	0.01	0.08	-0.03	0.00	-0.00
Mezzanine	**0.12***	0.04	0.05	**0.03****	**0.15****	**0.04****
1st Floor	**0.14****	**0.20****	0.00	0.04	**0.25****	**0.16****
2nd Floor	**0.23****	**0.28****	0.12	0.00	**0.20****	0.07
3rd Floor	0.05	**0.34****	0.14	-0.01	**0.29****	**0.24****

* Values marked in bold with * were significant at the 0.05 level and ** at the 0.01 level.
Negative correlations are shown in green, low R2 (<0.2) are shown in grey and above that in black.

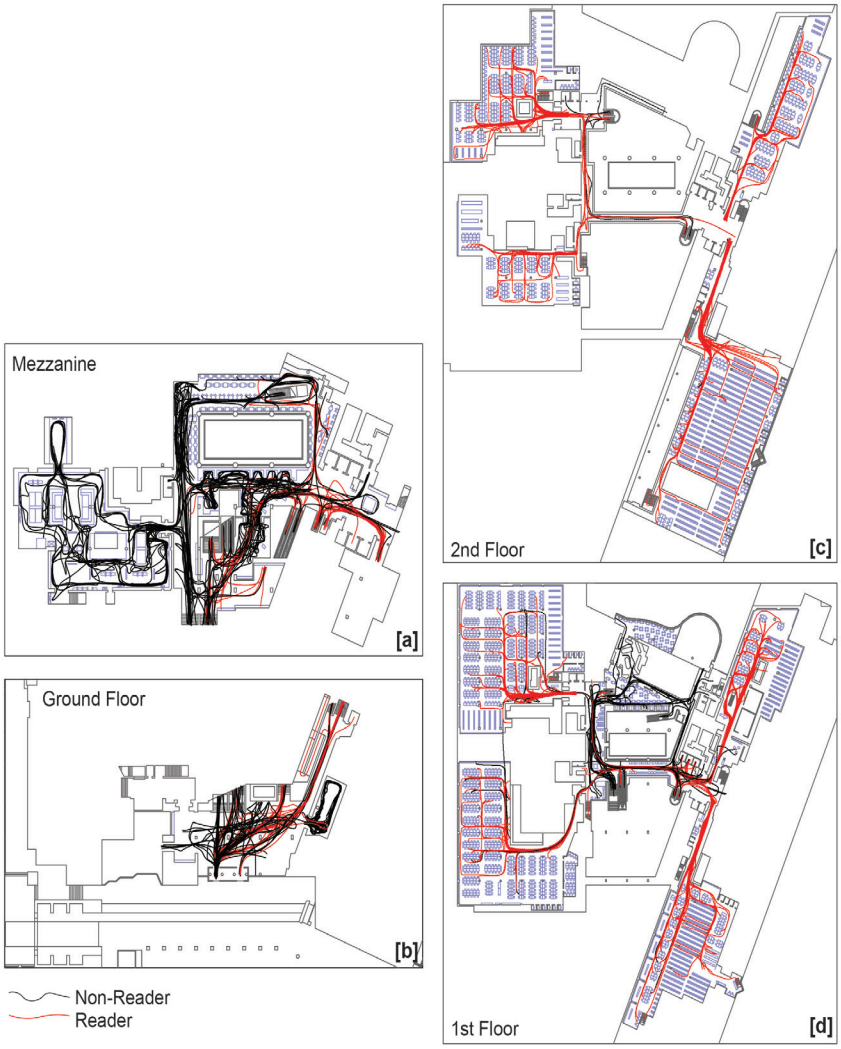

Figure 2 a-d. *Movement traces of 427 Readers (red) and 149 Non-Readers (black) on the ground floor, mezzanine, first and second floor.*

es through the entrance, however it is not necessarily also the most integrated place in the building. Buildings with many floors often show the integration core placed around the geometric centre of the building as a whole, which is also is the case for the British Library, where the most integrated areas are found on the first floor. Again, this distorts the correlation between movement flows and configuration.

The relationship between different user groups such as Readers and Non-Readers can also be analysed as a matter of the interface constructed by the building to bring people together or keep them apart. First of all movement traces of the two different user groups can be compared visually. It can be seen in figure 2a-d that movement flows between Readers and Non-Readers overlap in certain parts of the building such as the ground floor, mezzanine and first floor, yet, there are many spaces with a distinctive dominance of either Readers (upper floors, circulation, staircases, Reading Rooms) or Non-Readers (exhibitions, café, canteen). It can also be seen from the traces that Readers (shown in red in Figure 2a-d) move in a rather targeted fashion with straight routes, while Non-Readers (shown in black) tend to wander more aimlessly along curvy paths.

The degree of co-presence between Readers and Non-Readers can also be investigated statistically by correlating total numbers for each group across the different locations in the building. With gate-count data a correlation of $R2=0.28$, $p<0.0001$ is obtained, showing that Readers and Non-Readers distributed rather differently across the building: areas with high counts

of Readers showed rather low counts of Non-Readers and vice versa. This means the building creates a controlled interface between the different user groups and keeps them apart rather than bringing them systematically together. It seems the Library offered attractive spaces to each group separately; they co-existed rather than cohered and came together.

In summary, the analysis of movement flows has highlighted that the British Library is a predominantly strongly programmed building: overall flows do not follow configurational logic consistently and different user groups with distinct usage patterns (Readers vs Non-Readers) were separated to a high degree. A further analysis of strong and weak programming in buildings as a function of the diversity and distribution of activities will follow in the next section.

5.2. Diversity and distribution of activities

To investigate diversity and distribution of activities, a two-step approach was followed: firstly it was analysed whether primary and secondary activities differed according to their spatial properties of connectivity and integration (i.e. visual Mean Depth), retrieved from the VGA. This will highlight whether certain activities show preferences for areas with high or low direct visibility (connectivity) and for areas with strategically short or long visual paths (mean depth). Secondly, the distribution of activities will be brought together with the functional allocations of spaces to analyse whether specifically allocated areas attract usage differently from the overall building averages.

Regarding the spatial logic of primary activities, i.e. sitting, standing and walking as individual behaviours and interactions as group behaviours, highly significant differences of connectivity and mean depth can be found between these activities in a statistical Analysis of Variance (ANOVA). Results of the ANOVA tests are shown in Table 2; Figures 3a-b show the VGA of the building for connectivity and mean depth. Differences in connectivity are more pronounced, leading to a higher coefficient of R^2=0.07 ($p<0.0001$), while mean depth only shows an R^2=0.01 ($p<0.0001$), yet both are highly significant effects also due to the large sample size. The fact that connectivity seems to relate more strongly to user behaviour is in line with findings reported in previous research (Haq, 2003).

In detail, interactions have the lowest average connectivity (284 VGA pixels, which equates to an area of 284 sqm, since the VGA grid was set to 1x1m); interactions are also relatively high in mean depth compared to other activities (5.83 on average), which means people interacted in rather segregated and smaller areas. Since the average values of connectivity and mean depth for the whole building are 585 and 5.95 respectively, all observed activities were more integrated than the building average (<5.95). Standing and walking took place in medium sized areas (354 and 418 sqm on average), but walking clearly happened in the most integrated places (lowest average mean depth of 5.54), while standing occurred in the most segregated ones of the places observed (MD=5.89). Sitting enjoyed the largest view-sheds with an average of 606 sqm, which is larger than the building average; this is clearly due to sitting being most prominent in the reading rooms, which are also relatively large in size.

Secondary activities also showed significant differences between the direct and strategic visibility of various

Table 2. *Number and statistics [mean, standard error] of spatial properties connectivity [CONN] and mean depth [MD] of observed primary activities from ANOVA tests.*

Activity	Count	Mean [CONN]	Std Err [CONN]	Mean [MD]	Std Err [MD]
Interaction	591	284.836	16.535	5.83134	0.03167
Sitting	6137	606.156	5.131	5.75574	0.00983
Standing	904	354.165	13.370	5.88449	0.02560
Walking	697	418.305	15.226	5.53567	0.02916

* Connectivity values larger than the building average and mean depth values lower than the building average are highlighted in red.

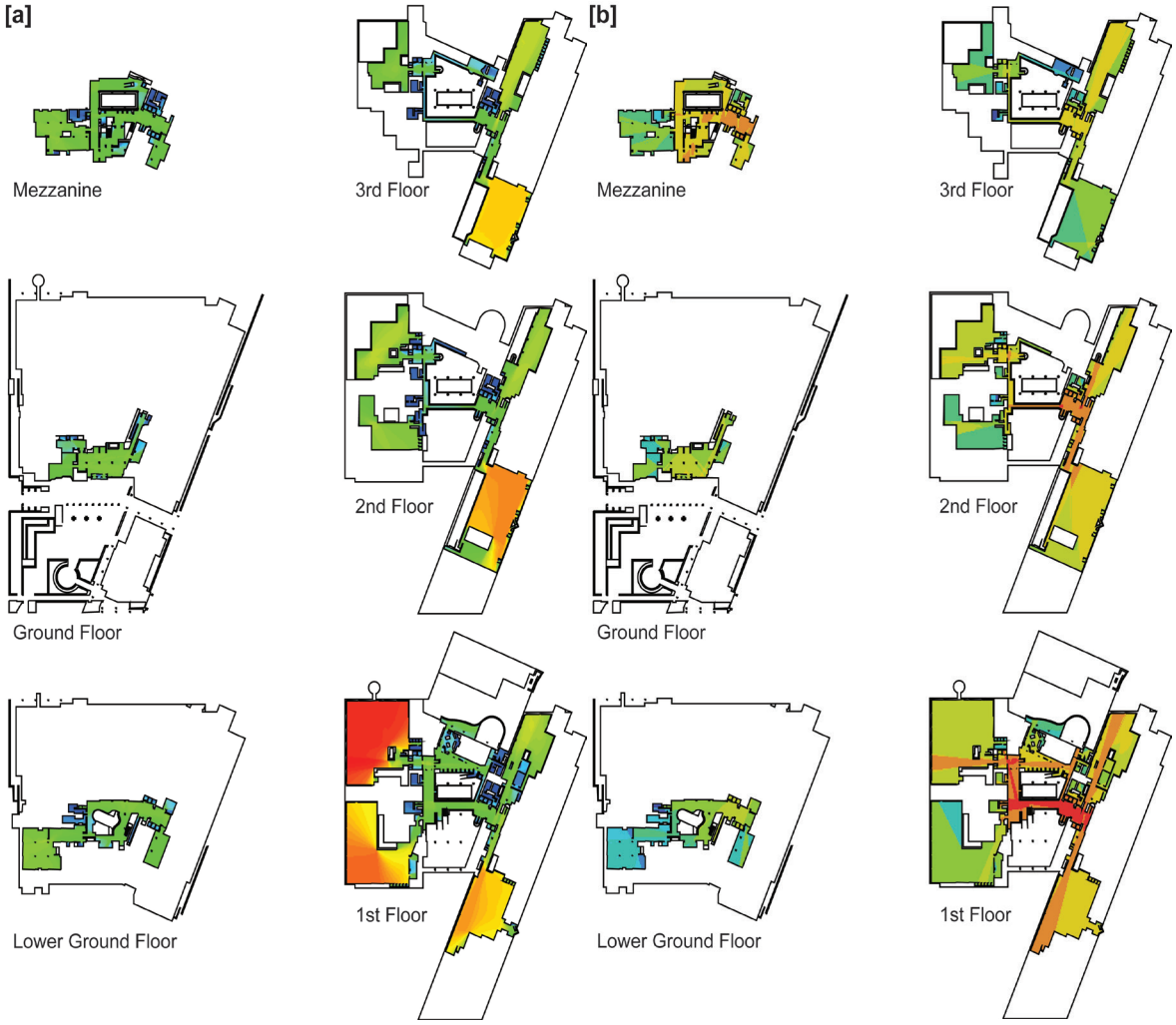

Figure 3 a-b. *Visual Graph Analysis of the British Library: Connectivity (a) and Mean Depth (b).*

behaviours; the ANOVA results for connectivity were highly significant ($p<0.0001$) with an $R^2=0.27$, while $R^2=0.10$ was obtained for mean depth ($p<0.0001$). Details are presented in Table 3. Interestingly for instance, laptop users preferred smaller and more integrated areas, especially if they were also talking (CONN=265, MD=5.47), whereas laptop users reading in parallel sat in larger and more segregated areas (CONN=929, MD=6.03). People looking around tended to be in very integrated areas (MD=4.37); similarly those occupants using their phones were also found in integrated spaces (MD=4.70).

This means people seek out specific types of spaces in order to go about specific activities. Spatial configuration therefore played a role in distributing activities in space according to its degree of local and global integration and segregation. Some activities however, for instance shopping or engaging with an exhibition could be argued to be driven by the functional programme rather than the preference for a particular spatial character of integration or segregation, hence the distribution of activities by function will be investigated next.

In order to do so, the 22 different observed activities[3] were clubbed together into ten broader core activities (as listed in figure 4a-b), for instance all activities involving talking (Eating Drinking Talking, Exhibition Talking, Laptop Talking, Reading Talking) were grouped together into 'Talking' rather than distinguishing by additional activities. This procedure also ensured that results were comparable to those reported by Capille and Psarra (2013), who distinguished nine different activities in their study of public libraries. The method presented by Capille and Psarra to quantify the degree of programming in a library by calculating the distribution of activities for the

[3] *Only the data collected in 2009 was taken into account, since in 2010 sitting in some areas (specifically in the Reading Rooms) was not broken down further (e.g. reading, laptop usage, etc.) and this would distort the following analysis.*

Table 3. *Number and statistics [mean, standard error] of spatial properties connectivity [CONN] and mean depth [MD] of observed secondary activities from ANOVA tests.*

Activity	Count	Mean [CONN]	Std Err [CONN]	Mean [MD]	Std Err [MD]
Bag Cloak Locker	22	213.261	77.42	6.70176	0.15607
Eating Drinking	133	211.232	31.49	6.03696	0.06348
Eating Drinking Laptop	7	159.619	137.26	6.51515	0.27669
Eating Drinking Reading	12	203.076	104.83	5.54179	0.21132
Eating Drinking Talking	115	218.767	33.86	5.88826	0.06826
Exhibition	297	341.650	21.07	6.05512	0.04248
Exhibition Talking	33	402.942	63.22	6.17684	0.12743
Laptop	819	399.693	12.69	5.40453	0.02558
Laptop Reading	311	929.028	20.59	6.03018	0.04151
Laptop Talking	34	265.319	62.28	5.47077	0.12554
Lift	4	333.188	181.57	5.93379	0.36602
Looking	19	323.947	83.31	4.37154	0.16794
Order	74	153.375	42.21	6.14963	0.08510
Phone	47	314.777	52.97	4.69967	0.10678
Reading	420	514.097	17.72	5.75063	0.03572
Reading Talking	70	155.665	43.40	6.37389	0.08750
Searching	8	195.458	128.39	6.21016	0.25882
Shopping	66	180.619	44.70	7.03216	0.09011
Sitting	3534	752.236	6.11	5.76712	0.01231
Standing	208	430.779	25.18	5.75250	0.05076
Talking	880	275.280	12.24	5.74283	0.02468
Walking	625	425.535	14.53	5.57156	0.02928

* Connectivity values larger than the building average and mean depth values lower than the building average are highlighted in red.

building as a whole and comparing it to the distribution in different functional areas was applied here. In addition to investigating functional areas (Figure 4a), the variation across the different floors was also scrutinised (Figure 4b).

Looking at the building as a whole, it can be seen that using a laptop is the most predominant activity in the British Library, amounting to 40% of all observed activities, followed by talking (20%), reading (15%) and sitting (8%). While the mix of activities in the corridors and café strongly resembled those found in the entire building (see figure 4a), some more variation was found in the foyer (where 19% of people engaged with exhibition material

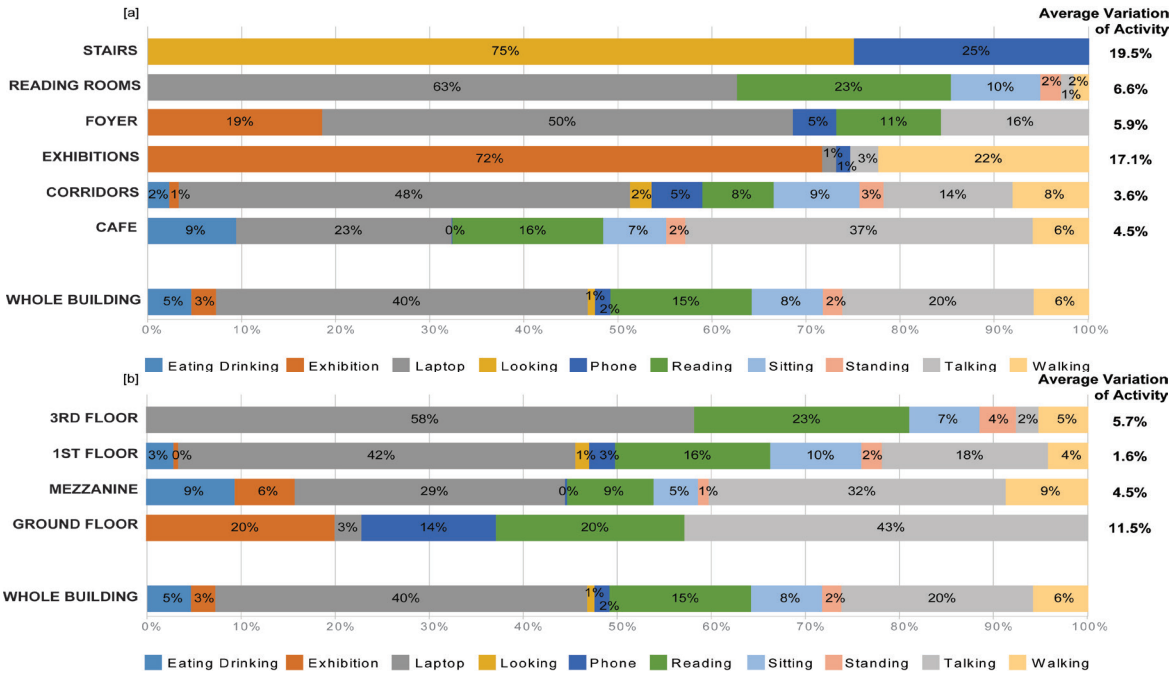

Figure 4 a-b. *Distribution of ten core activities (based on 2009 data) across different functional areas [a] and floors [b] of the building in comparison to the whole building average. The lower ground and 2nd floor were not observed in 2009. Percentage values are rounded.*

rather than just 3%) and the reading rooms (where laptop use rose to 63%); the highest level of variation however was found on the staircases and the exhibition spaces themselves. The figures obtained for the average variation in those two areas are in line with the ones reported by Capille and Psarra for a strongly programmed building. This means that some parts of the British Library enact a strong programme, distributing and shaping behaviours and the mix of activities in addition to the effect of spatial configuration, as argued in the previous section.

Analysed floor by floor, the mix of activities on the mezzanine level, as well as the 1st and 3rd floors is comparable to the overall building distribution; only the ground floor showed significant variation, which is due to the high number of specialised functions on the ground floor, for instance exhibition spaces. The role of the ground floor in helping people to orient themselves also becomes obvious in the disproportionately high percentage of people using their phones (14% rather than 2%) and more than twice the percentage of people talking (43% rather than 20%).

To summarise, the British Library is a building combining both elements of weak programming (since activities showed statistically significant preferences for integrated or segregated spaces) and strong programming (since activities were distributed unevenly across the functional areas of the building).

5.3. Rhythms and temporal patterns of usage

In addition to the analysis of the overall diversity of activities unfolding in the British Library, changes in usage patterns over time were also investigated.

Regarding the distribution of movement, it can be seen that busy areas (with high flow intensity) during the week are not necessarily those also populated to a higher degree on weekends. A correlation of gate counts based on traces for the week versus the weekend reveals an R^2=0.32 ($p<0.0001$), which means that 32% of flow intensity on the weekend can be predicted by flow intensity during the week, but the majority of flow intensity across the different spaces differed between weekday and weekend. Generally speaking, the upper floors showed higher usage intensity during the week, whereas lower floors showed more intensive usage over the weekend.

Another interesting difference between weekday and weekend usage patterns can be revealed by re-doing the analysis of variation of connectivity values of each activity (as done in section 5.2 and shown in Table 3 above), but now executed separately for weekday versus weekend. The same was repeated for mean depth. The ANOVA is highly significant for all datasets ($p<0.0001$); correlation coefficients for connectivity were higher for weekdays (R^2=0.33) than weekends (R^2=0.20), whereas it is the other way around for mean depth with lower coefficients for weekdays (R^2=0.14) than weekends (R^2=0.34). It should be noted that coefficients generally rise by splitting the data by day of the week, which shows that different patterns were evolving on weekdays versus weekends. The differences between average connectivity and mean depth values between weekday and weekend are plotted in Figure 5a-b.

The most pronounced differences can be observed for activities involving the use of laptops and talking, but also for reading, walking and sitting. People working on their laptops preferred smaller (CONN=234) and more integrated spaces (MD=5.04) on the weekends as opposed to weekdays (CONN=451, MD=5.51); this is even more pronounced for those using their laptop alongside reading (CONN=236 vs CONN=944 and MD=5.31 vs MD=6.03). Reading itself as well as sitting showed a similar preference for smaller and more integrated spaces on the weekends than on weekdays, despite the fact that weekend observations were done on Saturdays, which meant the Reading Rooms (as rather large and segregated spaces) were open. Talking occurred in similarly sized areas on weekdays and weekends, however, on weekends talking happened in much more integrated spaces (MD=5.27 rather than 5.96). Possibly it could be the case that users sought

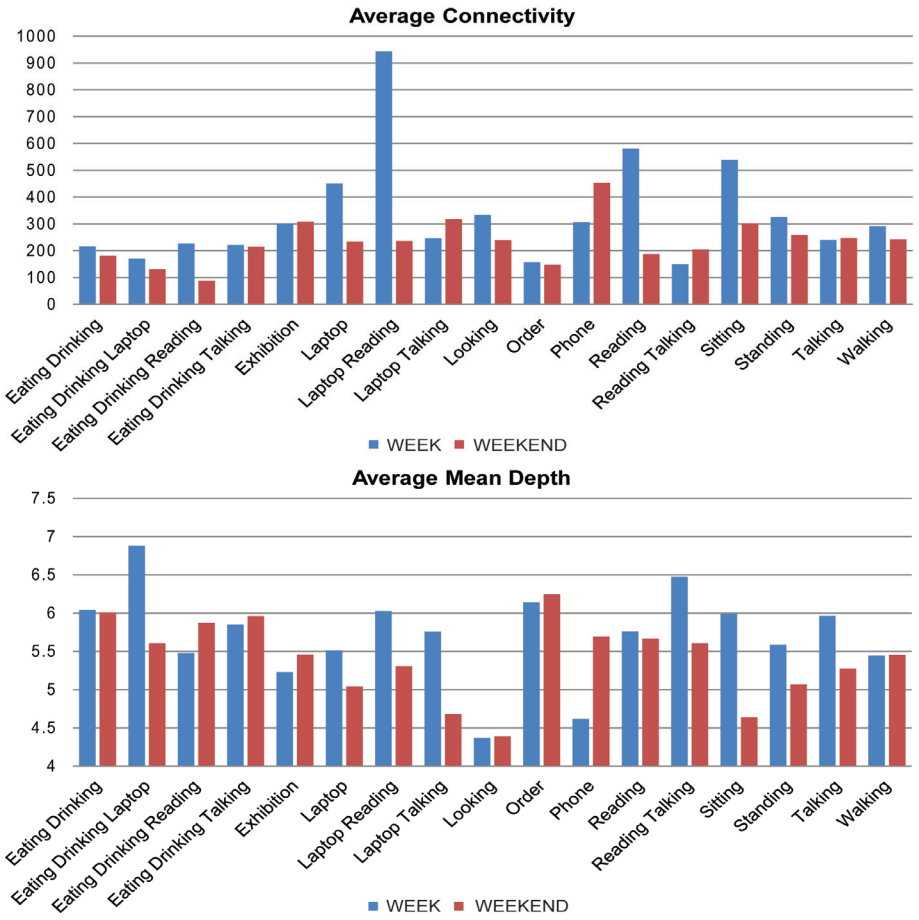

Figure 5 a-b. *Average connectivity [a] and average mean depth [b] of activities on weekdays versus weekends (based on 2009 data only, since weekend observations were not done in 2010).*

more socialising opportunities on weekends and thus preferred to place themselves in more buzzy (hence integrated) areas.

Looking at the distribution of activities across functional areas again, not much variation appeared between weekday and weekend, however interesting differences can be detected over the course of the day (as illustrated in Figure 6).

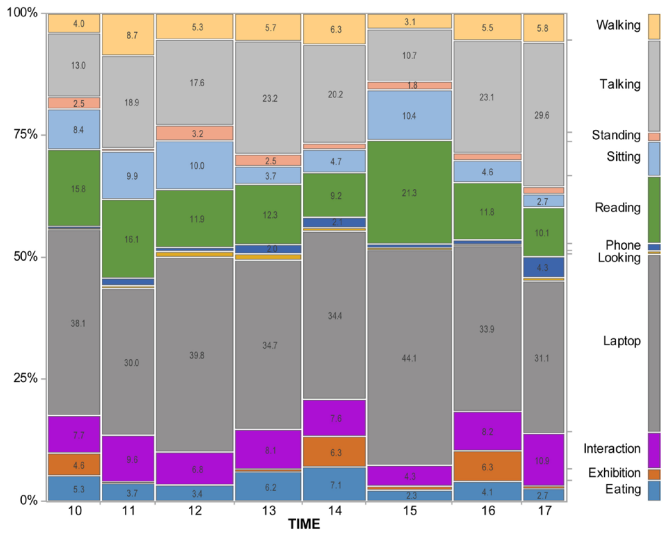

Figure 6. *Variation of ten core activities plus interactions between people (based on 2009 data) over the course of the day. The time marked in the diagram highlights the starting time of the observation period.*

Concentrated work such as reading or working on a laptop peaks in the afternoon (from 3-4pm); eating peaked at lunchtime and in the early afternoon as expected (between 1-3pm); social activities such as talking and interactions peaked mid-morning (11-12pm), at lunchtime (1-2pm) and in the late afternoon (5-6pm); and the engagement with exhibits showed a high in early morning (10-11am) after lunch (2-3pm) and in the afternoon (4-5pm).

In summary, this analysis highlights how temporal patterns of usage evolve, creating a rhythm of activities and experiences over the course of a day with shifting preferences and locations of activities between weekday and weekend. Qualitative accounts of people's engagement and behaviours in the

British Library (Thomas, 2013) seem to underline this interpretation of user experience of rhythms and temporal patterns, where people chose to change activities as the day went on.

5.4. Emerging communities and usage patterns

Last but not least, specific usage patterns of emerging communities and particular groups of people can be investigated. From qualitative observations we know that a group of people using the British Library for working purposes queue outside the building every morning to take up seats in front of the Kings Library on the first floor, which offered good seating, nice individual lighting and power plugs in addition to the free wifi available in the whole building. Those spaces shown in Figure 7 offer both opportunities for socialising (as they are in a highly frequented route) as well as solitude (by the nature of the furniture) and were the most popular seats in the Library, essentially being occupied first thing in the morning and throughout the whole day. As an emerging community of so called 'nomadic workers', people have come to know each other and watched out for other people's belongings.

Other specific communities of people with particular space usage patterns were entrepreneurs using the IP and Business Centre of the British Library. All areas connected with the IP and Business Centre showed disproportionate numbers of males (four times as many males as females as opposed to a ratio of 1:1.15 for the building as a whole), but also higher numbers of users in the age range 40-60 (1.7 older people per younger people in contrast to a 1:1.03 ratio for the entire building).

Other areas with an uneven distribution of users by additional demographic information include a female dominance in the Social Sciences Reading Room (3.4 females per male) and the shop (1.6 females per male) and a higher presence of older people (40-60 years of age) in the Philatelic Exhibition (3.6 older people per young person), whereas twice as many 20-40 year olds as compared to 40-60 year olds were found around the areas of the Folio Society Gallery.

Figure 7. *Community of nomadic workers in front of the Kings Library. Photograph by Kerstin Sailer.*

This account of emerging communities and differences in the distribution of people with certain user demographics highlights how the building affords behaviours by particular groups of people in distinct ways.

6. Conclusions: On diversity, dynamics and built form

This paper presented evidence from observations of space usage patterns in the British Library in conjunction with an analysis of the spatial configuration of the building and its affordances for user behaviours. It was shown how movement flows in the British Library mostly defied configurational logic. In addition to a rather controlled interface between different categories of people such as Readers and Non-Readers, this drew a picture of a strongly programmed building. However, the analysis of the distribution of activities across space highlighted that activities and behaviours of people followed configurationally defined preferences and thus showed weak programming. Functional areas in contrast, in particular exhibition spaces and to a smaller degree the foyer and Reading Rooms maintained elements of strong programming, since the mix of activities there differed significantly from the overall building average, pinpointing the many ways in which the functional allocation and affordances of different spaces drove usage behaviours. The analysis of temporal dynamics, emerging communities and different user experiences over the course of the day

and between weekday and weekend highlighted how the building constantly evolved, shifted and changed, depending on perspective.

The main contribution of this paper is therefore the conceptualisation of a building as a layered, dynamic and changing experience rather than as a definite entity impacting collective user behaviour in one particular way. It also shifts the attention of Space Syntax analysis away from top-level collective user behaviours to more nuanced and detailed understandings of the diversity and dynamics of the relation between configuration and space usage.

Due to the nature of the used data set, this paper has clear limitations; issues include inconsistent data (for instance different observation standards in 2009 and 2010), missing data (for instance not all areas were covered equally well), and possibly limited quality of the data due to issues with interobserver reliability, specifically given that the data was collected by Master's students in their first weeks of their degree. Wherever possible those limitations were taken into account for the different types of analysis.

To conclude, this paper has investigated the diversity of different space usages of a building over time in relation to its spatial configuration. It has explored both temporal dynamics as well as usage diversity to incorporate a more differentiated perspective on who uses a building when for what purpose, or in short the 'multiplicities of occupation' (Groák, 1992). Space Syntax can offer a fruitful framework for this exploration beyond mere aggregate and collective social patterns. Future research could focus on the nuances of temporal and user-specific dynamics more systematically to address what Brand (1994) called a 'shocking lack of data' on building usage. He highlighted the need for studies of all kinds of buildings in use and what changes from hour to hour, day to day, week to week, month to month and over the years. 20 years later this is still an open research question, which this paper hopes to contribute towards.

Through its architecture and 'versatility of form', the British Library has clearly managed to be a space that 'builds relationships with individuals' as evident in the diverse and dynamic usage patterns showcased in this paper.

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