Everyday use of urban street spaces: the spatio-temporal relations between pedestrians and street vendors: a case study in Yuncheng, China

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Abstract

In contemporary Chinese cities dynamic street vendors are a common presence, frequently occupying spaces where many people regularly walk, leading to functional changes to the streets. This research aim was to examine the everyday use of urban streets at a micro-scale, to explore spatio-temporal relations between the fixed built environment and the ways in which vendors and pedestrians co-produce walkable space and walking behaviours over time. Using field observation and behaviour mapping, we compared spatio-temporal data and spatial patterns of street activities over four daily periods of three urban street spaces in the medium-sized city of Yuncheng. The results indicate that such activities produce environment-behaviour interactions and socio-spatial relations, which leads to an understanding of how city life occurs. The conclusions suggest that vending is important for giving life to urban areas and increasing residents' physical activity, so that urban governors and designers should consider how to facilitate it better.

1. Introduction

1.1 Walkability and pedestrians

Owing to the multiple benefits of walking (e.g. promoting public health, enhancing social

interaction, increasing land value and reducing environmental pollution), improving urban walkability is becoming an increasingly significant research topic (Saelens et al., 2003; Kashef, 2011; Speck, 2013; Duncan et al., 2015; Sun et al., 2016; Brookfield et al., 2017). Most studies, especially in developed countries, have linked neighbourhood walkability to physical activity such as: (a) the influence of spatial configuration and neighbourhood characteristics (e.g. population density, land use diversity and street connectivity), which can be used quantitatively to evaluate a walkable environment (e.g. Hillier et al., 1993; Frank et al., 2010; Cerin et al., 2013; Koohsari et al., 2016); and (b) use of ecological models and perceived environmental attributes (e.g. walking for recreation or transit, local culture, gender and age difference) to explore context-specific behaviours with individual, physical, social and economic factors (e.g. Pikora et al., 2006; Giles-Corti et al., 2005; Frank et al., 2010; Cerin et al., 2013). Such studies often measure walkability at a macro-scale and their focus may be different from the smaller-scale places where people undertake everyday activities.

While useful, these approaches to understanding walkability are incomplete, ignoring many micro-level features of urban streets and pedestrians. For instance, walkability could be subjectively studied in relation to sense of place, such as human-scale and complexity or the necessary and optional activities in a specific street (Lynch, 1960; Jacobs, 1961; Ewing et al., 2009; Gehl, 2010). Mehta (2008) notes that the street can serve everyday needs and create place-attachment, thereby affecting pedestrians' attitudes and perceptions. Whyte (1980) argues that pedestrian behaviours can be impacted by street components such as the presence of shade and seating. Some studies indicate that compared to other street components, street edges can provide social, multisensory and experiential importance to pedestrians, such as more visual engagement while walking (Gehl, 2010; Simpson et al, 2018). Even different pedestrian groups' relative distances to one another might relate to proxemics in a cultural context (Hall, 1966; Buchan et al., 2006; Golicnik et al., 2010). In light of environmental affordances (Gibson, 1986; Heft, 2010), several studies indicate that sensitive pedestrians (e.g. older people, women, children and low-income groups) are generally more influenced by the same environment than other people (e.g. Unt et al., 2014; Brookfield et al., 2017; Jensen et al., 2017). As such, we contend that the ambiguous characteristics of pedestrians vary widely and could be further distinguished in relation to the specific purpose, population and behaviour in the context of Chinese urban streets.

1.2 Chinese cities and street vending phenomenon

Rapid urbanisation in China usually leads to urban developments which ignore the everyday life of urban residents and the need for walkable neighbourhoods. Since China's economic reforms in the late 1970s, the number of people walking and cycling has declined, with many negative consequences (Su et al., 2017). For instance, the prevalence of obesity increased from 8.6% in 2000 to 12.9% in 2014, among a population of 1.37 billion (Tian et al., 2016). In recent years, a few studies have focused on walkable environments but they tend to ignore the nuanced understanding and features (e.g. fast development, high density and temporal use of streets) of Chinese cities at the micro-scale (e.g. Sun et al., 2015; Zhou et al., 2017; Fan et al., 2018). These studies are mostly quantitative, consider larger scales and are based on the application of western urban models. This has led to three challenges: (a) inconsistent results across different cities and studies, due to discrepancies of culture, economy and society; (b) a focus on larger cities due to limited data and resources available for smaller Chinese cities; and (c) few time-related and context-specific reflections due to the difficulty of measuring heterogeneous and dynamic pedestrian activities.

Street vendors are common in residential neighbourhoods, dynamically occupying space where many people regularly walk (Cupers, 2015; Sun et al., 2016; Flock et al., 2016). Although research indicates street vending to be a sign of urban vitality, its inherent mobility is generally considered problematic by Chinese urban administrators (Huang et al., 2014; Xue et al., 2015). According to the Lefebvrian proposition of social space (1991), vending space incorporates two integrated systems: (a) the urban street layout and environment produced by social elites that strengthen and reflect the power of governance and regulation, and (b) spatial appropriation and temporary alterations of street layout in order to serve the heterogeneous needs of residents' everyday lives. Thus, there is a need to expand the research focus beyond street vending itself and to view its mobility as a positive way to produce transient walkable spaces with multiple attachments. This walkable space is neither a pre-existing nor a timeless container which pedestrians fill and move around in; rather it is temporarily co-produced by street vendors and pedestrians.

1.3 Research aims and objectives

This paper emerges from urban walkability research related to street vending practices (Sun et al., 2016). The key question is how are urban streets temporarily re-appropriated by mobile street vendors and dynamically used by pedestrians? From the review above, it can be seen that the empirical basis and temporal data are lacking at a micro-scale (Fan et al., 2018). The research aim, therefore, is to explore the multiple spatio-temporal relations of street vendors and pedestrians by studying three specific street spaces in Yuncheng, a medium-sized Chinese city, in order to understand how they operate and how they influence walkable space at different times of the day. The objects of this study are activity categories and dynamic uses presented as two research questions:

- How can everyday street activities be distinguished according to the paired types of street vendor and customer, specific population characteristics and walking behaviour?
- How do spatio-temporal patterns vary and how do street vendors and pedestrians co-produce a transient walkable space?

2. Methodology

2.1 Case study sites and research process

Yuncheng is the southernmost prefecture-level city in Shanxi province, and typical in terms of rapid economic growth (increasing GDP by 7.8% annually) and having a high population density (5,275,300 inhabitants/14,233 km^2) (Yuncheng Statistical Yearbook, 2016). According to the most recent Chinese census data (2010), 42.4% of the Chinese population live in cities of this scale (i.e. from 4 to 8 million inhabitants). The research focused on three street spaces in residential neighbourhoods characterised by an abundance of street vending, much pedestrian movement and high built density in the surrounding area but less-integrated streets. Figure 1 presents a comparison of the three sites' characteristics.

	Site 1 Huaidong Street	Site 2 Weinan Street	Site 3 Hanxin Street
Location	The east of the city centre	The east of the city centre	The east peri-urban area
Observation area	Approx. 1000 m²	Approx. 2000 m²	Approx. 1700 m²
Spatial features	Alley entry Narrow street Shortcut Developed space Mixed land use - medium Population density - high Temporary variation - low	Cul-de-sac Wider street Semi-enclosed space Developed space Mixed land use - high Population density - high Temporary variation - medium	Alley entry Wider street Open space Underdeveloped space Mixed land use - low Population density - medium Temporary variation - high
Spatio-temporary variations The photos were taken on 13th July 2017			

Figure 1 Similarities and differences of the three selected study sites in Yuncheng.

The methodology comprised four phases: a pilot study, workshops for data collection, GIS database assembly and data analysis. The pilot study developed a detailed protocol for the workshop. This included selecting observation sites and times, preparing site plans, analysing site contexts and summarising activity types. The workshop was designed to collect data simultaneously from the three sites, to refine the activity types, and to discuss potential results, together with 16 observers from various disciplines and different universities, thereby ensuring inter-rater reliability and multiple perspectives when reflecting on the findings. The recorded data was entered into a Geographic Information System (GIS) and the behaviour observations were analysed both spatially and temporally.

2.2 Developing behaviour mapping

Behaviour mapping is an objective tool to study the relationships between human behaviour and the environment, through observing different activities in selected places without intervention by the observer (Golicnik et al., 2010; Unt et al., 2014; Ghavampour 2017). It connects subject-

related behaviours with the properties of space and time, making it possible to ascertain environment-behaviour interactions.

The original method has five steps: an initial site survey to collect site characteristics; development of a symbolic coding system for the types of activities associated with demographic characteristics; a method of associating the symbols or codes (e.g. activity, age and gender) to the site plan during a survey; iterative site surveys and recording of the microclimate at different periods; combined mapping and comparative analysis. However, our pilot study identified several challenges in applying this method as it stands:

- It is only valid in places with relatively fixed behaviours and lower population density (e.g. parks or squares). Other places (e.g. markets or streets) involve many constantly moving pedestrians and changing behaviours that are impossible for observers to record.
- During the survey, each observer must use the symbolic coding system by hand. The low efficiency leads to a challenge for synchronous recording in different streets.
- The mapped data cannot be checked since the activities disappear shortly after the recording, so data quality is difficult to assure.

2.3 A workshop for data collection

To overcome the limitations noted above, a number of developments to the method were undertaken: (a) to replace the on-site mapping by hand with use of repeated panoramic photos taken from elevated positions to mitigate the limitations on busy streets with various activities and higher pedestrian movement; (b) to include a field-workshop with a team-based technique of observation to deal with the limitation of synchronous recording at different sites; and (c) to use GIS for recording the data extracted from the photos to deal with the limitations of a symbolic coding system and repeating checking. Observing from an elevated viewing position enables an observation area of up to 1000-2000m^2 to be covered. 13 photos per hour were taken at each site (i.e. a photo was taken every five minutes). An extra spot for a test observation at Site 2 was used to confirm the validity of this averaging approach. The weather (i.e. approximate temperature, rainfall, cloud and wind levels) and special annotations (e.g. impression, light and noise) were noted separately.

To facilitate simultaneous data collection, 16 observers were recruited, trained together, and then spread among the three sites. The data collection was carried out over a week from 11 to 17 July 2017. The recording periods included four different hours of the day (07.00-08.00, 11.00-12.00, 16.00-17.00, and 19.00-20.00), in order to sample the various uses of spaces according to the rhythm of everyday life (e.g. 'morning commute to work', 'hot period and lunchtime', 'commute to home after work' and 'evening leisure').

Data entry into the GIS involved converting the activity recorded in each photograph into georeferenced points with associated attributes, which could be edited flexibly, replacing the clumsy graphical symbolic coding system. Twenty-four activity types (Table 1) were identified during the workshop. The photos used for the GIS database were archived and used to check the database randomly for data quality control (i.e. the third limitation). A filtering system was developed to separate activities into one of five layers ranging from explicit behaviours to ambiguous behaviours (Table 1): (a) the *selling layer* identified the different types of street vendors; (b) the *buying layer* comprised the customers (i.e. paired with the associated vendors); (c) the *specific (non-vendors or buyers) population layer* was identified from occupational features or uniforms; (d) the *specific (non-vending or buying) behaviour layer* was distinguished by others (e.g. children most often emerged with adults in streets); and (e) the remaining people were classified to the last *ambiguous layer* as common street activities (e.g. walking or sitting).

2.4 Database creation and analysis techniques

The first day of data collection was designed for initial observation and practice. The other six days' data (i.e. the panorama photos) were entered in digital form into GIS ArcMap 10.5 (ESRI). Of the 13 photos taken per hour, seven were input to the GIS database while the other six were retained as back-up or for quality control. The individual locations could be accurately related to the site settings using clearly identifiable features (e.g. pavement crack, building façade, curb, tree, public furniture or a vendor's stall). The completed GIS database included 72 hours and 504 photos in total from the three sites.

The detailed recording of each individual location, activity type, gender, time and date created a spatially explicit GIS database (i.e. displaying environment-behaviour interactions) that could be

used for two different analyses (i.e. statistical and spatial). There was no clear boundary of street vending spaces, so comparing the proportions is more appropriate for this study than absolute numbers. The database allowed cross-comparison with other factors (e.g. micro-climate, site setting and field observation). The three sites were analysed separately, then the spatio-temporal patterns were combined and compared with social relations.

3. Results

3.1 Variety of everyday street activities

During the observation periods, 4259 people were registered at Site 1, 6449 at Site 2 and 7112 at Site 3. Table 1 shows twenty-four activities within five layers at the three sites, illustrating that how the proportions, gender numbers, and workday/weekend means of the everyday activities differed.

Walking, standing, sitting and cycling were included in the ambiguous behaviour layer and their proportions were generally higher than the other four layers in the three sites (e.g. the highest proportion was walking). From Site 1 to Site 3, although the total numbers of people had an increased trend, the proportions of walking and cycling as a mode of active travel showed decreasing trends (Walking: 28.6%, 20.9% and 19.7%; Cycling: 13.4%, 11.1% and 8.9%). Walking females were slightly more numerous at Sites 1 and 2, but cycling females were lower in all three sites.

Aside from the ambiguous layer, the selling and buying layers showed that cooked food vendors formed the highest proportion (11.9%, 19.4% and 10.4%) and their buyers were relatively numerous (5%, 17.4% and 7.8%). At Site 3, the paired activities selling and buying fruits (5.4% and 3.6%) and vegetables (4.3% and 6.6%) were also significant. The female vendors were almost equal at Sites 1 and 2, although much lower in number at Site 3. However, female buyers were more numerous at all three sites.

A specific population type was identified as ‘urban managing’ at Site 3. The urban managers who inspect the street to check for illegal activities appeared once during the survey period. They indicated that street vendors must vacate the area. Another specific behaviour comprised two

common children's activities (i.e. children playing and adults walking with children). The number of boys playing was greater than girls. However, the number of girls walking with adults was greater than boys.

Table 1

Activities performed in the three sites in male/female number, mean during workday and weekend, total number, and total percentage (abbr. V-vending & B-buying).

Activities	Site1 Male	Female	Weekday M	Weekend M	Total	%	Site2 Male	Female	Weekday M	Weekend M	Total	%	Site3 Male	Female	Weekday M	Weekend M	Total	%
Selling Layer																		
Food v	244	262	85	83	506	11.9	644	606	199	227	1250	19.4	417	321	110.8	147.5	738	10.4
Fruit v	72	71	18.5	34.5	143	3.4	66	86	21.8	32.5	152	2.4	268	115	66.5	58.5	383	5.4
Veg v	9	1	0.8	3.5	10	0.2	26	2	3.8	6.5	28	0.4	287	22	58.5	37.5	309	4.3
Sundry v	22	34	8	12	56	1.3	3	4	0.3	3	7	0.1	68	107	29.3	29	175	2.5
Service v	98	67	28.8	25	165	3.9	2	0	0.5	0	2	0	41	0	5.8	9	41	0.6
Meat v	0	0	0	0	0	0	4	39	8	5.5	43	0.7	0	0	0	0	0	0
Buying Layer																		
B food	89	125	38.3	30.5	214	5	529	591	153.5	253	1120	17.4	285	269	79	119	554	7.8
B fruit	37	57	15	17	94	2.2	17	29	6.5	10	46	0.7	88	167	41	45.5	255	3.6
B veg	0	2	0.5	0	2	0	3	19	2.8	5.5	22	0.3	111	359	83.5	68	470	6.6
B sundry	9	5	2.5	2	14	0.3	0	3	0.3	1	3	0	39	38	14	10.5	77	1.1
B meat	0	0	0	0	0	0	10	39	8.3	8	49	0.8	0	0	0	0	0	0
Specific Population Layer																		
Cleaner	4	32	3.8	10.5	36	0.8	53	17	13.5	8	70	1.1	6	1	1	1.5	7	0.1
Delivery	9	1	2	1	10	0.3	54	0	8.3	10.5	54	0.8	5	0	1	0.5	5	0.1
Police	4	0	0.8	0.5	4	0.1	3	0	0.8	0	3	0	0	0	0	0	0	0
Manager	0	0	0	0	0	0	0	0	0	0	0	0	19	0	4.8	0	19	0.3
Flyer	0	27	0	13.5	27	0.6	0	0	0	0	0	0	0	0	0	0	0	0
Specific Behaviour Layer																		
Child playing	22	16	5.5	8	38	0.9	90	59	17.8	39	149	2.3	40	15	9.3	9	55	0.8
Child walking	4	21	6.3	0	25	0.6	47	130	25.3	38	177	2.7	3	23	6	1	26	0.4
Adult playing	0	0	0	0	0	0	0	0	0	0	0	0	64	10	9	19	74	1
Dog walking	0	0	0	0	0	0	3	2	0.8	1	5	0.1	0	0	0	0	0	0
Ambiguous Behaviour Layer																		
Walking	570	646	208.3	191.5	1216	28.6	636	710	227.3	218.5	1346	20.9	745	655	222.8	254.5	1400	19.7
Standing	307	248	82.5	112.5	555	13	379	250	93.5	127.5	629	9.8	577	403	150	190	980	13.8
Sitting	286	288	91	105	574	13.5	319	261	116	58	580	9	591	317	131	192	908	12.8
Cycling	327	243	96.5	92	570	13.4	380	334	114.8	127.5	714	11.1	399	237	103.8	110.5	636	8.9
Total	**2113**	**2146**			**4259**	**100**	**3268**	**3181**			**6449**	**100**	**4053**	**3059**			**7112**	**100**

3.2 Temporal patterns in numbers

Table 2 illustrates the observation period, temperature, proportion of people, correlation and number of street vendors and non-vendors (i.e. various pedestrians) during the four periods at the three sites. In general, most people at the sites emerged at 19.00-20.00 and 07.00-08.00, and fewer emerged at 11.00-12.00 and 16.00-17.00. At Site 1, the changing proportions during the four periods fluctuated slightly compared to other sites. Site 2 had a striking contrast in that more than half the people emerged between 19.00-20.00 (50.1%). The proportion at 07.00-08.00 (28.1%) was more than double that of 11.00-12.00 (10.3%) and 16.00-17.00 (11.4%). At Site 3, the changing proportions were extremely pronounced, particularly at 19.00-20.00 (73.0%). The proportion at 07.00-08.00 (16.1%) was around three times that of the other two periods (5.3% and 5.6%). The number of street vendors was also positively correlated to non-vendors during the four periods, although there were some discrepancies. The correlations at 16.00-17.00 were weakest at Sites 1 and 2 (6.6 and 5.4), but at Site 3 it was weakest at 07.00-08.00 (7.4).

Table 2
Period of observation, number of days, times, temperatures, total people, vendors and non-vendors.

Period of this study	12th -17th July 2017			
Time of day	7.00-8.00	11.00-12.00	16.00-17.00	19.00-20.00
Temperature (M/Range)	29℃/27-31℃	38.8℃/34-45℃	34.3℃/28-41℃	31.8℃/25-38℃
Site 1 (N=4259) %	30.2	19.9	16.1	33.8
Site 1 Correlation V/N	3.68	2.75	**6.6**	4.0
Site 1 Vendors/Non-vendors	275/1012	226/621	**90/594**	289/1152
Site 2 (N=6449) %	28.1	10.3	11.4	50.1
Site 2 Correlation V/N	2.9	3.1	**5.4**	3.4
Site 2 Vendors/Non-vendors	470/1344	161/502	**116/622**	734/2500
Site 3 (N=7112) %	16.1	5.3	5.6	**73.0**
Site 3 Correlation V/N	**7.4**	2.3	2.4	3.1
Site 3 Vendors/Non-vendors	**136/1012**	113/263	117/278	1280/3913

** Special weather: Light rain 7.16 16 .00-17.00, Cloudy 7.17 16.00-17.00 & 19.00-20.00*

3.3 Effect of street edges and changing behaviours

The composite mapping of 168 photo layers showed that a street/pavement edge effect divided the use of the spaces (Figure 2 all lines). Firstly, the pavement edges were popular with street vendors. They appropriated the pavements for temporary market spaces, forcing the pedestrians to mix with other traffic in the roadway, negating the purpose of the street design intended to separate vehicle traffic from pedestrians. The street behaviours formed three categories. In front of the pavement edge, it could be fast transit behaviours (e.g. walking or cycling). Around the

edge, it could be commercial behaviours (e.g. standing, buying or selling). Behind the edge, it could be longer stay behaviours (e.g. buying, sitting or eating). Secondly, the building edges to the rear of the street vending strip area were used by local people for relatively stationary behaviours (e.g. sitting, standing, watching, having conversations and adults/children playing). Thirdly, the invisible edges (Figure 2 red lines) in the larger and emptier spaces were related to the building edges and the entries to spaces.

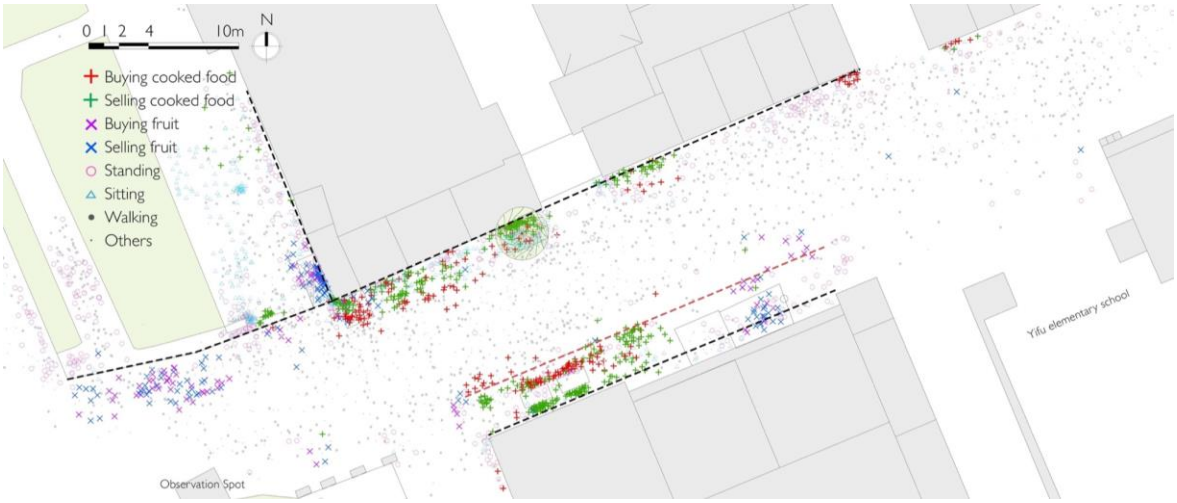

Figure 2a Site 1's spatial patterns and edges of main activities. The red line represents an emerging edge.

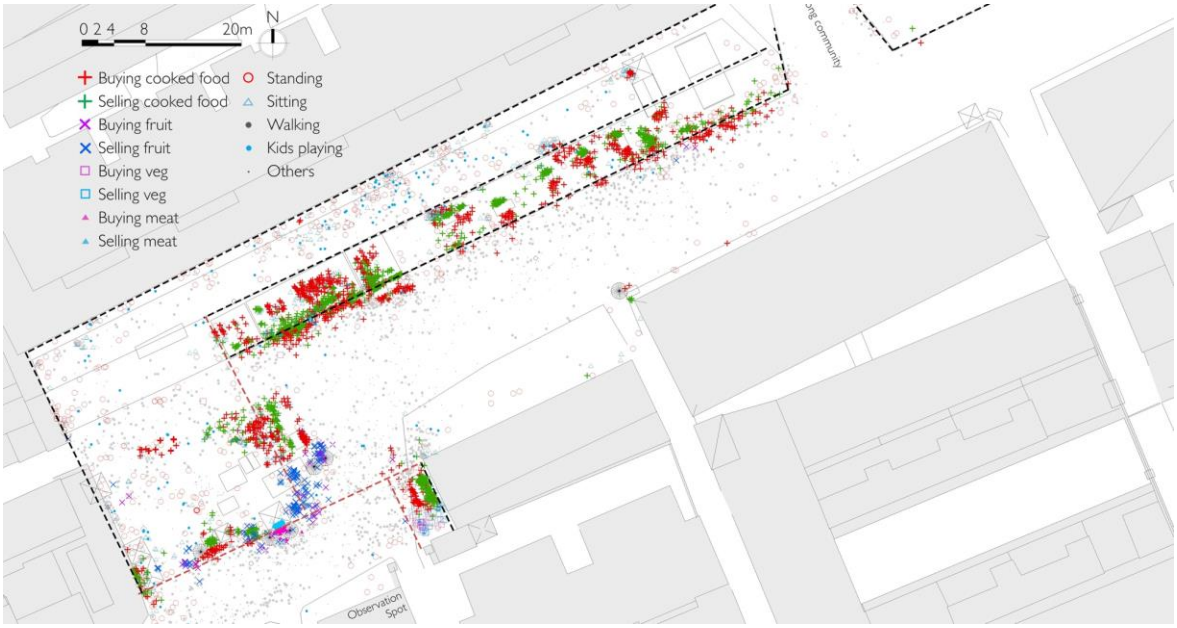

Figure 2b Site 2's spatial patterns and edges of main activities. The red lines represent emerging edges.

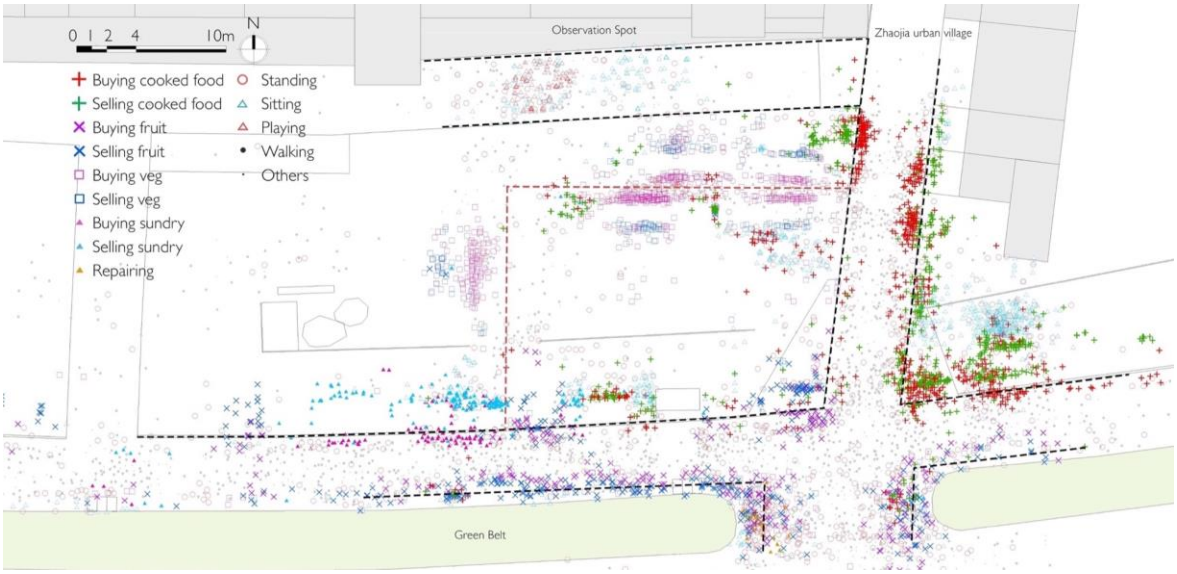

Figure 2c Site 3's spatial patterns and edges of main activities. The red lines represent emerging edges.

3.4 Everyday spatio-temporal patterns

Through the composite mapping (Figures 3-5), the environmental affordances and the temporal variations of the three sites could be further explored. At Site 1, because of shade, the tree cluster spot (Figure 3 cluster 2) was always present except at 19.00-20.00; the cluster at the building corner (Figure 3 cluster 1) followed the shadow movement from right to left from 07.00-08.00 and the pedestrian flow (Figure 3b purple line 5) was dramatically higher on the north side at 16.00-17.00 due to the building shadow. Aside from 16.00-17.00, a popular cluster spot on the south side (Figure 3 cluster 4) comprised street vendors selling cooked food. At a special cluster spot in the alley entrance, street vendors providing services (e.g. a locksmith) engaged with older people sitting and chatting throughout the day, showing a strong social interaction (Figures 2a & 3 cluster 3).

Figure 3a Site 1's spatio-temporal patterns at 07.00-08.00 and 11.00-12.00.

Figure 3b Site 1's spatio-temporal patterns at 16.00-17.00 and 19.00-20.00.

At Site 2, due to the location of shadow at 16.00-17.00, people were concentrated on the north-west side in front of the buildings (Figure 4b purple line 7). The most popular clusters were on the pavement north side (Figure 4 clusters 5 & 6) and at the entry to the gated community (Figure 4 cluster 3), especially at 07.00-08.00 and 19.00-20.00. At 19.00-20.00, the emptier space became a small market square with a crowded atmosphere (Figure 4b clusters 1 & 2),

which temporarily altered the pedestrian movement along the emerging edges (Figure 2b red lines).

Figure 4a Site 2's spatio-temporal patterns at 07.00-08.00 and 11.00-12.00.

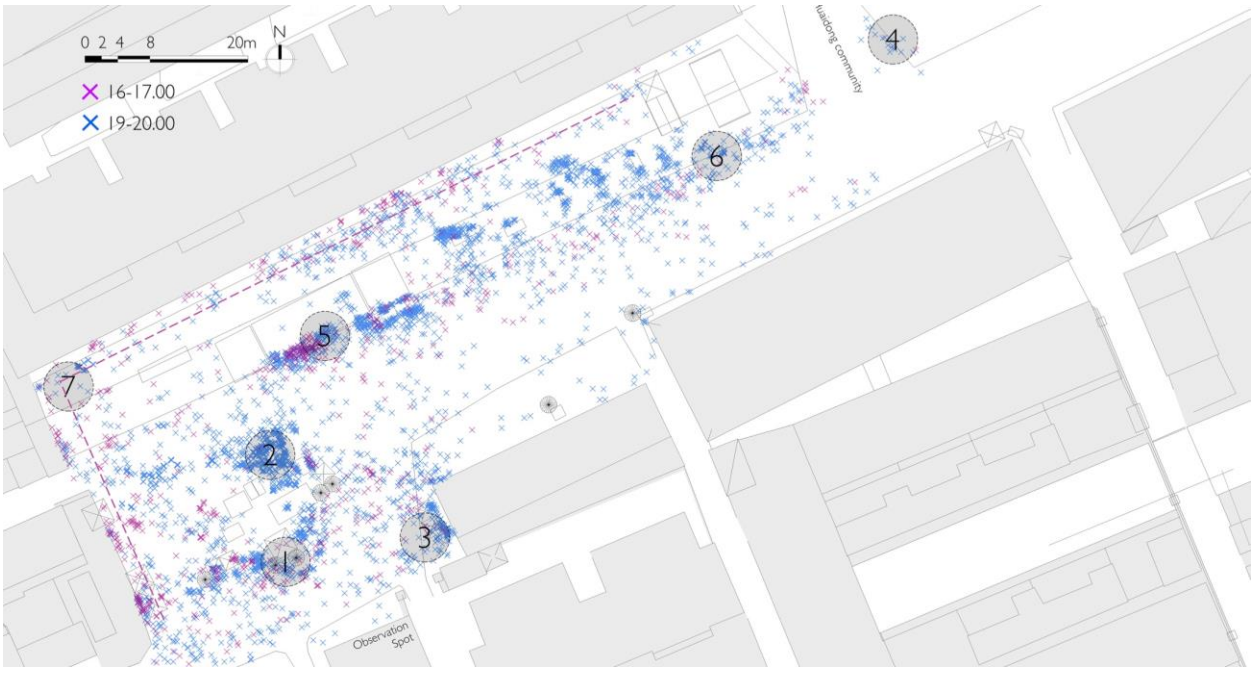

Figure 4b Site 2's spatio-temporal patterns at 16.00-17.00 and 19.00-20.00.

At Site 3, a few clusters (Figure 5a clusters 1-3, partly sheltered by canopies) were concentrated at the entrance at 07.00-08.00. All clusters had almost disappeared by 11.00-12.00 and 16.00-

17.00. At 19.00-20.00, all clusters re-appeared (Figure 5b clusters 1-9) but with a scattered distribution; the pedestrian flow (Figure 5b) was significantly influenced by the edges (Figure 2c lines) and temporarily guided by the street vendors.

Figure 5a Site 3's spatio-temporal patterns at 07.00-08.00 and 11-12.00.

Figure 5b Site 3's spatio-temporal patterns at 16.00-17.00 and 19-20.00.

4. Discussion

4.1 Site characteristics and temporal relations

Examination of the spatio-temporal patterns across the three sites revealed two crucial co-operations of street environmental affordances (Gibson, 1986) and socio-spatial practices (Lefebvre, 1991) at different times and sites. Site 1, an alley connecting central urban areas, could be used as a shortcut (Figure 1). The analysis shows that the correlations between vendors and non-vendors over four periods were looser than at other sites (Table 2). The walkable space characteristics of 'a higher residential population, necessary transit and a short distance to link to surrounding environments' existed in the city centre (Ewing et al., 2009; Gehl, 2010; Speack, 2013), maintaining pedestrian flows during hot periods of 11.00-12.00 and 16.00-17.00. The 'narrow street' characteristic limited street vending practices, which could not engage enough 'activities' during recreational periods (e.g. evenings or weekends). The weakest correlation between vendors and pedestrians was at 16.00-17.00 (Table 2), because 'meals three times a day' was not related to this period and most vendors disappeared.

Although Site 2 is also connected to central urban areas, it has a wide pavement space with a cul-de-sac in an old neighbourhood (Figure 1). Despite 'lower accessibility' correlating negatively to walkability, other spatial characteristics corresponded with most studies on a walkable environment of 'a higher residential density and various amenities within a walkable distance' in the city centre (e.g. Mehta, 2008; Frank et al., 2010; Cerin et al., 2013; Fan et al., 2018). As such, the weakest correlation was at 16.00-17.00, similar to Site 1 (Table 2). However, classifying street vending as 'supplementary amenities' (Sun et al., 2016), the spatial characteristics of 'abundant amenities' and 'large street space' led to street vendors concentrating more on a single type of selling - cooked food (19.4%) and its paired activity - being remarkably higher (17.4%) than Sites 1 and 3 (Table 1). Unlike Site 1, more people emerged in the evenings (Table 2) and the numbers of pedestrians buying cooked foods dramatically increased at weekends (Table 1).

Site 3, in a peri-urban area, has a wide pavement with an open emptier space (Figures 1 & 6). The area is underdeveloped with few amenities and many new high-rise residential buildings nearby. Many western studies indicate that with a lack of amenities, low population density and less integrated streets in peri-urban areas, residents depend more on private cars and the resultant streets lack a vivid street life (e.g. Hillier, 1993; Mehta, 2008; Kashef, 2011; Speck, 2013; Koohsari et al., 2016). However, the results here show the opposite, due to the high density in

Chinese cities (Tables 1-2 and Figure 5), illustrating a greater variation of everyday activities during the four periods than other sites. It became extremely active in the evening (Table 2, Figures 5b and 7), generating heterogeneous activities as ‘a self-organised and transient hub for everyday commerce’ at recreational periods. Unlike the city centre (Sites 1 and 2), the weakest correlation between pedestrians and vendors was at 07.00-08.00 (Table 2), due to ‘lacking breakfast amenities’ in the peri-urban area - being supplied by only a few vendors who serviced numerous customers. This appears similar to the Lefebvrian idea (1991) that greater pedestrian activity might not be generated mainly by the built environment but rather co-produced by the basic and frequent needs of local everyday life. We believe that this temporary lack of amenities in the peri-urban area of Chinese cities should be considered when a process of rapid development leads to higher population density, which might be a significant opportunity for street vendors who could serve abundant and diverse customers. Unlike the city centre, socio-spatial practice operates its principal power in engaging street activities and serving the needs of everyday life, particularly in the early mornings and evenings. It is also worth noting that the many transient workers on local construction projects would be gradually replaced by new residents. We anticipate that the transition of different pedestrians in the rapidly developing areas would result in changing types and emergence times of vendors over time.

4.2 Dynamic use of street space

As noted earlier, the two systems of environmental impacts and social relations were further examined via the composite mappings. The results (Figures 3-5) illustrate that street activities followed shadow movements (Whyte, 1980; Ewing et al., 2009; Golicnik et al., 2010), depending on the tree location, street corner and building height according to their orientation and street width. As direct sunlight disappeared, three spatial features (i.e. street corner, community entrance, and the area in front of buildings and behind the strip of street vending territories) became significant for the relatively stationary behaviours of local people. This suggests that small yet important areas could be better designed to facilitate temporal but specific street behaviours.

The composite mappings demonstrate a special spot at Site 1 (Figures 2a & 3 cluster 3) where some older people sat on chairs taken from a nearby shop for a long time. ‘Seeing people and

chatting with long-standing vendors' seemed to be important in this old neighbourhood. At Site 3 some middle-aged people emerged in the evening and used tables/chairs from a nearby restaurant to play games (e.g. poker or Chinese chess) (Figure 5b cluster 9 and Figures 6-7 location C). 'Social playing with discussing, analysing and debating a game together' might be not directly related to other emerging people, but correlated to the building position, thermal comfort and recreational periods. As such, although older, middle-aged people and street vendors in urban streets are a sign of 'vitality' (Jacobs, 1961; Gehl, 2010; Cupers, 2015; Sun et al., 2016), the results might also reflect 'profit and accessibility', 'loneliness and leisure', 'social playing and temporary territory' and 'micro-climate and thermal comfort'. Pedestrians and vendors were not only affected by the presence of shade and seating (Whyte, 1980), but also co-existed with heterogeneous motives which suggests how movable furniture has a design appeal with various temporal compositions for Chinese living street space.

The edge effect is not only the most visually stimulating but also offers dynamic and multisensory aspects for people, compared to other spatial components (Golicnik et al., 2010; Unt et al., 2014; Simpson et al., 2018). This study distinguishes the three types of street edges (Figure 2) and the temporary alterations of street functions: (a) building edge (e.g. the shadow movement and movable furniture) temporarily affected pedestrians to linger in these places; (b) pavement edge and (c) invisible (emerging) edge were frequently appropriated by street vending that altered pedestrian movement. The various socio-spatial practices that emerged in the street edges led to changes in the perceptual qualities of the street environment, which aligns with urban design concepts, such as imageability, enclosure, human scale and complexity (Lynch, 1960; Ewing et al., 2009). The large street spaces were (re-)appropriated at particular periods and transformed into a human-scale space. The different movements were mixed by vendors in order to improve their visibility to potential customers. The street vendors temporarily provided the transparent and permeable features of street edges. The vending strip, as a form of enclosure, provided protection for relatively stationary behaviours (e.g. sitting, watching, having conversations and playing in front of the building edges) from the faster-moving vehicles and pedestrians. These dynamic and diverse spatial appropriations of everyday activities together increased the complexity of streets.

Returning to the gender equity of everyday activities (Jensen et al., 2017), this study shows many micro-details in Chinese street space. Other studies have considered walking and cycling together as a mode of active travel (e.g. Saelens et al., 2003; Giles-Corti et al., 2005). Our results show that walking females were statistically more numerous in the city centre (i.e. Sites 1 and 2) and less common in the peri-urban area (Jensen, 2017), but cycling females were lower at all three sites (Table 1). At all sites, female buyers were greater in number, as they still generally take care of their family; boys usually played together for a long time in front of buildings (e.g. Figure 2b and Figure 4b purple line 7) where they could occasionally be seen by their guardians at a greater range (<3.6m); and girls tended to be more linked to their guardian's short-term movement at an intimate distance (<0.45m) and most likely overlapped with the buying layer. This suggests that gender behaviours in Chinese public street space are multifaceted and that patterns have been unconsciously formed since childhood.

4.3 Paired activities and their spatio-temporal characteristics

Another aim of this study was to distinguish the everyday street activities in order to explore the spatio-temporal features among various vendors, their paired customers and other co-existing pedestrians. This study developed three aspects of time-activities (i.e. fast and slow pedestrians) (Golicnik et al., 2010), three activity types (i.e. necessary, optional and social motives) (Gehl, 2010; Simpson et al., 2018) and proxemics of four distances (i.e. intimate <0.45m, personal 0.45m-1.2m, social 1.2m-3.6m and public 3.6m-7.6m) (Hall, 1966; Buchan et al., 2006; Golicnik et al., 2010) in relation to the Chinese context of vending-walking space (e.g. Figure 8). Based on the results of the on-site observation, we propose the following possible meanings for three paired activities, in line with the idea of societies producing their own special spaces (Lefebvre, 1991):

Firstly, the most significant paired activities (i.e. buying and selling cooked food) tended to re-appropriate larger spaces regularly (wide pavements or emptier spaces), where there was greater accessibility to pedestrian movement, in addition to providing enough space for their customers to stay for a while (e.g. eating). The spatial characteristics of these clusters (Figure 2) had a close social distance with a clear boundary between sellers and their buyers (e.g. standing in front of vendors to wait for the food or sitting behind the vendors to eat). Their emergence was likely

during all four periods, but the forms of eating varied throughout the day. For instance, spots serving the necessary breakfast needs of commuters going to work were clustered in the early morning (i.e. fast vending). However, spots selling dinner to people pursuing leisure were scattered in the evening (i.e. slow vending), although the number of people was highest then (Table 2).

The second-most popular paired activities (i.e. selling and buying fruit) preferred space with the highest pedestrian accessibility (e.g. Figures 6 & 7 location G). This vending type usually had one or only a few products (possibly seasonal fruit) for sale, appearing occasionally and irregularly during peak hours (most likely in the evening recreational phase). Buyers only paused to make an impulse purchase before continuing their walk (Sun et al., 2016). The fruit vendors were serving intermittent needs as an optional activity, unlike those selling breakfast to provide immediate and necessary sustenance. The features of selling, time spent, movement dynamics and relationship to purchasers were mixed with pedestrian movement and were positioned to be as close as possible to pedestrians regardless of whether they were blocking their movement (Figure 2). Furthermore, another specific group of urban managers (Figure 1) appeared in the evening at Site 3, drove fruit vendors away and broke the paired activity. The sub-category of selling fruit implies ‘highest accessibility’, ‘closer personal distance to pedestrians’, ‘blocking pedestrian movement’, ‘highly flexible and mobile’, ‘difficult to regulate’ and ‘relating to peaking hours’ (Hall, 1966; Xue et al., 2015; Cupers, 2015). We also infer that this type has a complex relationship with local climate, local fruits and their ripening season. Its location appropriation, emergence time, single sales’ form and high mobility could be significant for Chinese urban governance and street layout design.

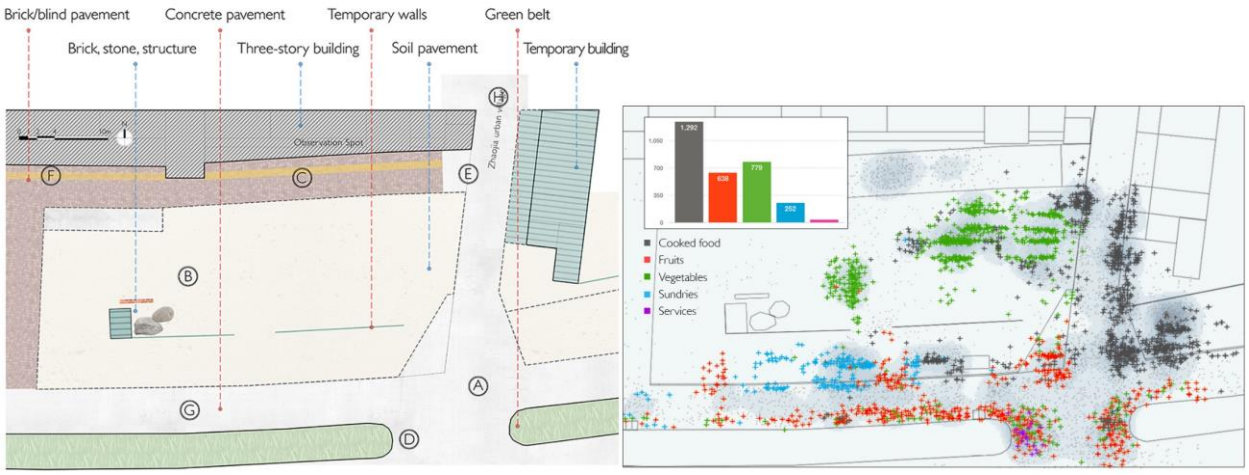

Figure 6 Site 3 maps: the site map (left), red lines mean formal elements and blues lines mean informal elements; the maps (right) of five paired activities and spatial intensity, darker grey means more intensive areas, overlapped 168 photo layers.

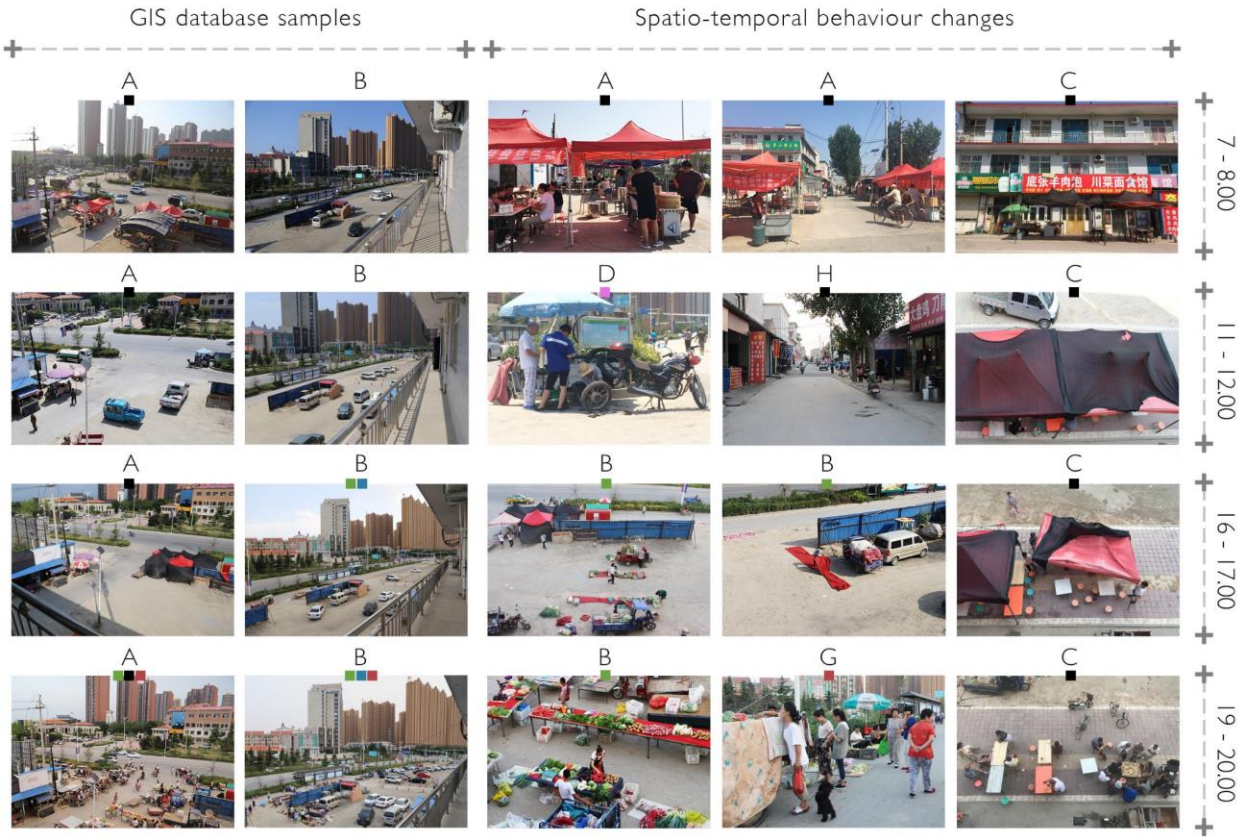

Figure 7 The photos at Site 3 show the complex socio-spatial practices and variations at four different hours.

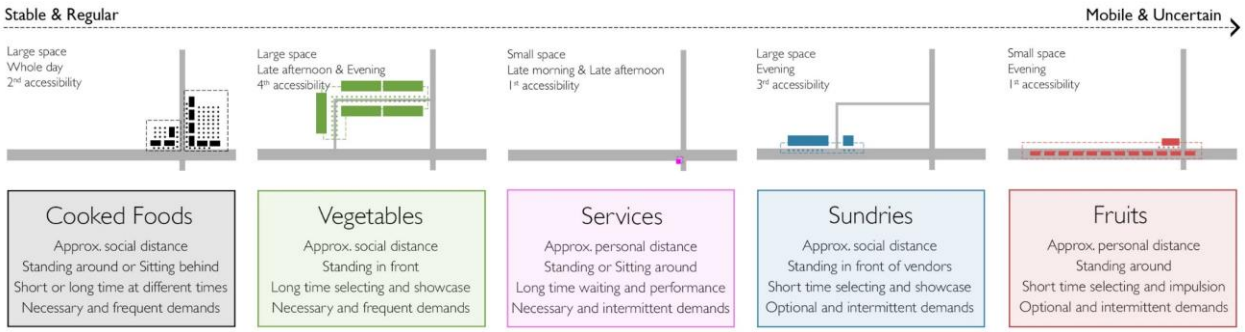

Figure 8 A diagram of five paired activities illustrates the features of spatio-temporal practices at Site 3.

Other less-popular paired activities also had special and recognisable time-spatial patterns, mainly at Site 3. The street vendors selling vegetables regularly gathered in an emptier space from the late afternoon until the evening, located away from established pedestrian pathways (Figures 2c, 6 & 7 location B). However, pedestrians who bought vegetables were one of the statistically higher user groups (Table 1). There was a social distance between sellers and buyers displaying their wares (Hall, 1996). Through observation, we found that this distance had a co-existing meaning - 'showcase' (time for displaying at 16.00-17.00) and 'selection' (time for buying at 19.00-20.00) - where the slower buyers would spend more time perusing the wares of the various vendors. The longer time taken to arrange the goods for sale led the vendors to avoid blocking pedestrian movement. Selling vegetables is closely related to the basic dietary requirements of nearby residents (Sun et al., 2016), which needs to co-create a bigger showcase space, requiring vendors to emerge together within a larger area rather than being fully dependent on pedestrian flows. This larger area was separated into several spots that were regularly appropriated by the individual vendors, becoming their own space over time.

5. Conclusions

Returning to the two research questions in this study, the first question has been answered through the activity filtering method (i.e. twenty-four street activities within five layers at four periods of the day in three urban/peri-urban street spaces). Based on the specific activities, sites' characteristics and periods, our answer to the second question is multifaceted. Most previous studies show that neighbourhood walkability (determined by population density, land use diversity and street connectivity) significantly impacts physical activities, in line with the spatio-temporal patterns at 11.00-12.00 and 16.00-17.00 in our study (i.e. higher temperature and

working periods). However, the patterns were significantly (co-) produced by socio-spatial practices at 07.00-08.00 and 19.00-20.00. In the early morning the street vending mainly provided breakfast to fast pedestrian flows. In the evening, plentiful slower street activities with diverse motives emerged, so that large street spaces became active and meaningful for social and commercial behaviours, particularly in the peri-urban area (i.e. lower neighbourhood walkability). Our study shows how the detail of dynamic street activities was temporally related to spatial features (e.g. pavement edges, emptier spaces, street corners, tree locations and surrounding buildings), micro-climate features (e.g. temperature and shade), and human features (e.g. genders, ages and various everyday needs). Moreover, although vendors only appropriated marginal street spaces, the perceptual qualities of streets appeared to be temporarily improved (e.g. imageability, enclosure, human scale and complexity). In short, the method incorporates both social and physical elements to provide a fine-grained picture of Chinese street activities, going beyond a general narrative of street vending itself or common studies on walkability, towards a precise empirical study into two crucial co-operations of environment-behaviour interactions and socio-spatial practices in specific urban spaces at different periods.

This method has its limitations. Some people were not mapped if they had not been clearly identified. It was possible to make occasional errors due to the distance from the observation points. Street vendors' canopies sometimes hid activities from view. Some activities had a longer duration making it possible for them to have been recorded several times. However, these limitations could be mitigated through the field observation and workshop discussion and by clear protocols as well as quality control and checking. As the sites selected were roughly comparable regarding such considerations, the potential limitations should be further tested in different cities and regions (e.g. different climates and development stages) before generalising it as a widely applicable method or applying the findings to other Chinese cities. For example, selling fruit depends on the local climate and season that might lead to different usage levels and spatio-temporal patterns. The specific weather (e.g. light rain and cloud) in this study may have influenced the uses of space that need to be further confirmed, perhaps by longer periods of observation over several seasons.

Street vendors, as transient and mobile amenity providers, could temporarily increase the range

of physical activities via heterogeneous tactics of mixed land use. This is a dynamic system of street spatial use, which may operate at all urban scales from the whole city down to the street corner, recalibrating urban street spaces at different times of the day and night. They should not be viewed as a design result but could be an approach of research-led design for understanding the production of specific walkable space via the environment-behaviour interactions and socio-spatial relations of local everyday life. The complex relationships and interactions could uncover many profound meanings to ever-changing street activities, which could be used to ascertain what roles designers might play in a particular street at different times (e.g. design for specific behaviours, group sizes or alternative needs). This study also presents a notion of flux in spatio-temporal patterns of vending-walking relations, differing from western studies and deserving sustained research (e.g. embodied street space). The knowledge and its application of designing active streets could benefit future policy-making and urban design practice for Chinese urban space, particularly at a micro-scale.

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