Urban Architecture: Eyes from the city
A Mobile Eye-Tracking Study of Urban Villages

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Abstract
This feasibility study assesses the strength and weaknesses of a novel methodology applied to the design of urban architecture to enrich the process of urban planning to satisfy the needs of a city's inhabitants. Specifically, a visual preference survey was conducted using eye-tracking technology to observe the influence of urban differing scales on the human visual experience. Using an observational design, two architectural conditions were introduced to section an urban village into a few predetermined areas and walking lines. The visual experience of ten participants was then collected using a mobile eye-tracking device. Results showed that people indeed have different visual perceptions when interacting with urban fabric, and that such perceptions change from a formal to a traditional scale design

Keywords
city, mobile eye-tracking, urbanscape, change of scale, edges, walking lines, visual perception

Introduction

In today society's rapid technological innovation, planners, architects, and scientists have been tasked with supporting businesses and policymakers in creating 'intelligent' cities that can balance contemporary human behavior with the capacity of the environment.

This paper proposes a framework for data collection methods to capture human responses elicited from the urban fabric. The purpose of this method is to benefit planners in innovating and regenerating the urban landscape. This position will be supported by a feasibility project, 'Living Shenzhen'[1] , conducted by the authors, with the aim to introduce citizens' desires and needs into the urban planning process.

The broad objective of the study underlying the project 'Living Shenzhen' was to explore the relationship between humans and the urban environment. More specifically, the aim was to understand people's responses to the developing integration between modern and traditional areas of the city. Using eye-tracking technology to capture the human visual experience, ten participants were monitored in the following urban fabric conditions: i) five different sectioned areas of the city district ii) predetermined walking lines. More recently, this work was reinterpreted to address the theoretical and empirical issues that emerged from the project in the exhibition 'Presenting Living Shenzhen'[2].

This paper will first present an overview of the background literature; it will then move on to discussing existing eye-tracking studies in urban architecture (Hollander et al., 2019; Sussman & Hollander, 2015) and the landscape (Junker & Nollen, 2019). Next, the urban fabric conditions implemented in the project 'Living Shenzhen' (sectioned areas, sectioned walking lines) will be evaluated within a selection of the relevant literature. Finally, potential ethical issues will also be addressed before suggesting future applications and research directions.

Background: City of Augmented Differences

This section will explore the argument for conducting the eye-tracking study in the city of Shenzhen. The word 'augmented,' included in the heading above, intends to express the magnitude of differences explored within urban architecture. Together with a historical and regulatory background, the existing contrast of the city will be analyzed in terms of scale between the spontaneous formation of the urban villages and the formal fabric of the planned city. Accordingly, a new paradigm named: The CITY OF EXACERBATED DIFFERENCE© (COED©) was introduced by Chuihuia, Inaba, and Koolhaas (2001) to capture the differences in the city as an architectural concept. Their view cannot be better described than in their own words:

"The traditional city strives for a condition of balance, harmony, and a degree of homogeneity. The CITY OF EXACERBATED DIFFERENCE© (COED©), on the contrary, is based on the greatest possible difference between its parts – complementary or competitive. In a climate of permanent strategic panic, what counts in the COED© is not the methodical creation of the ideal, but the opportunistic exploitation of flukes, accidents and imperfections. Although the model of the COED© appears brutal […] the paradox is that it is, in fact, delicate and sensitive. The slightest modification of any detail requires adjustment of the whole to reassert the equilibrium of complementary extremes" p. 29)).

Never before has a place gone through such a relentless building process as China has over the past thirty years, and no other city has matched Shenzhen's rapid growth in population and urbanization, being transformed within a very short time from a group of small villages of some thirty-thousand people into a city that, with its 14 million inhabitants, exceeds the biggest metropolis in the world (Huang, 2017, p. 65). Founded in 1979 in Baoan County, with the approval of the Chinese State Council, Shenzhen was officially declared the First Special Economic Zone (SEZ) of China in 1980 and rapidly urbanized from then on (Vogel, 2017, VII). In a few decades, this unique process led to a singular urban entity. The original agricultural and fishing villages within the Pearl River Delta area have been gradually surrounded by the rapidly urbanizing landscape, giving birth to the phenomenon of the so-called 'urban villages', or chengzhongcun 城中 (Bach, 2017b, 138). Urban villages are now a nationwide communal formation in China, and Shenzhen is one of the places where they first emerged, making the region a dazzling landmark for locals and foreigners alike while remaining a special space of negotiation and contestation.

Urban villages have become a key resource for researchers hoping to understand the process and effects of rapid urbanization in the Republic over recent years. The uncommon dynamics behind their development stem partially from their ambiguity concerning land rights. According to the Chinese Land Administration Law, all urban land belongs to the Chinese government while all agricultural land in rural areas belongs to the village collective. However, the so-called ownership of property within urban areas by citizen or non-government organizations is actually a long-term renewable lease. That is to say that the villages remain in control of their land even after the urbanization process, maintaining special collective property rights. In this regard, one often-unspoken conflict of interest arises when the city government develops new plans for public infrastructure around or inside the village, which constitutes a direct assault on villagers' collective landholding rights. In Shenzhen, the city municipal government has for a long time been cautious to impose a forceful authority against large collectives. On the other hand, throughout the years, villagers have proved themselves to be amazingly flexible and adaptable to the gradual changes in conditions and environment. First, they simply leased village land to small investors, then, they became builders of self-constructed housing on personal lots or even major landlords who set up small factories with particular specializations.

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[1] Bi-City Biennale of Urbanism/Architecture (UABB) of Shenzhen-Hong Kong 2019-2020 curated by Carlo Ratti.

[2] "72-hours Short-circuit" event in Rome of Open City, CHANGE: Architecture. Cities. Life

However, the real business opportunity came later when Shenzhen's population expanded. Villagers were able to establish large-scale accommodation leasing operations. Since the late 1980s, China's economic reform policy and Shenzhen's status as a SEZ made the region a destination for migrants from all over China, who were attracted to urban villages for their cheap rent and loose residential registration. Throughout the 1990s, some of the original villagers took advantage of the migrant population boom and began to cooperate with the newly emerging class of Chinese real estate developers. Better quality apartment complexes began to emerge around the villages, and these improvements attracted a new generation of white-collar migrants. In the early 2000s, this phenomenon has become so widespread that real estate developers began to favor urban villages for urban renewal projects, a phenomenon that slowly transformed Shenzhen's cityscape (O'Donnel 2017a; 2017b; 2017c. Bach 2017a; 2017b).

Under the influence of these counterposed forces, the urban village emerged because of the collision between the rapid urbanization under the current law of the market and the urban-rural dual structure inherited from the planned economy period. The result of these complex forces is today's infamous urban village landscape, full of densely constructed apartments (so narrow is the distance between the buildings that the locals call them the *'kissing buildings', qinwenlou* (亲吻楼), encircled by massive headquarters and a forest of 'hyperbuildings', as Koolhaas defines them (Chuihua, Inaba, & Koolhaas, 2001).

The locals seem to have little awareness of the richness that urban villages impart in terms of vernacular architecture, cultural, and social heritage. On the contrary Chinese people look at these places, at their best, as something to be soon replaced. Hints of change have been coming for a few years, some from the city itself, where gentrification in villages like Shuiwei reinterprets these fragments of the city according to a new vision, though not necessarily a better one.

One of the first official attempts to overturn this tendency towards urban villages came from the Biennale 2017. The curators, the local architectural firm Urbanus, decided to indicate the urban village as a paradigm for an alternative model of the contemporary city for their *City, Grow in difference* project. Forming spontaneously and evolving continuously, the urban village "[…] is the last frontier of Shenzhen Urban renewal campaign, and also the bottom line of a balanced urban development" (Hanru, Xiaodu & Yan, 2017, p. 49). To emphasize this theory, Urbanus chose to set up the main venue in Nantou, one of the most ancient villages in Shenzhen. The move perfectly matched with Rem Koolhaas's aforementioned description. The firm's curatorial statement posits that "Cities, Grow in difference" signifies a recognition and inclusion of things of different origins, status and values at social, cultural and spatial levels. It is a revolt against the mainstream culture ruled by 'centralism'. […] On one hand, the balance of contradiction and hybridity in the city shouldn't be broken arbitrarily. On the other hand, respecting otherness is a test of degree of tolerance of a city (Du, 2017, p. 49).

According to chief curators Hou Hanru, Liu Xiaodu, and Meng Yan, Shenzhen is currently experiencing a 'Post-Urban Village Era' and going through a second urbanization that threatens the survival of urban villages. Several questions concerning their management remain open. The urbanization of a city is driven by both top-down urban planning and bottom-up growth.

Residing in between past and present, order and chaos, legal and illegal status, and outside of the all-or-none system of value judgment, the urban village preserves the bottom-up spontaneous potential.

Pushing the limits of reforms, laws, institutions, and administrations, Shenzhen generated a transitional territory where conflicts and challenges are still cultivating an active mentality, an ability to reshape the national political vision to better fit in a specific local condition.

FTZ/SEZ: is the Zone a Modern Urban Space?

In this section, economic and socio-demographic factors are introduced as key components to understanding the urban dynamics of a case study. Recent empirical research has also shown the importance of economic structure and socio-demographic local contexts on urban complexity (Salvati & Carlucci, 2020). However, in the context of the present research, there is an emphasis on the relations between the economic aspects of the Free Trade Zones in Shenzhen — also called Special Economic Zones — and their urban development and architectural character. The remarkable view of Jonathan Bach (2017a, p. 30-32) is presented in his own words.

As Shenzhen grew, it had to find its place within two parallel processes: a global shift from labor-intensive manufacturing to knowledge-based economies, and increased competition from the ever-growing array of zones within China vying for both domestic and foreign attention. The diffusion of Shenzhen's market model across China means that the city can no longer lay unique claims to the sectors that once made it a destination for workers and investors alike. It faces serious domestic competition from Shanghai, Tianjin, Chongqing, and many other cities and regions, and increased international competitions from both low-wage countries like Vietnam and Bangladesh and high-end centers such Seoul, Singapore, and from its neighbor, Hong Kong. For Shenzhen to continue to produce, economic value required continuous adaptation of what Shenzhen was able to offer. As labor costs increased, it became less profitable to maintain small-scale factories. Already by 1985, low-skill manufacturing began to give way to more highly skilled demands from the emerging high-tech sector. High tech came to dominate Shenzhen, with flagship Chinese companies such as Huawei (telecommunications) and Tencent (Internet) and with globally famous (or notorious) branches of companies such as Foxconn making components for Dell, Hewlett Packard, and Apple. High tech is still the mainstay of Shenzhen, accounting for about 60 percent of its total industrial output, but is itself being retooled to focus on the 'new' industries of the twenty-first century, key among them e-commerce, non-

carbon-based energy sources (e.g., solar, wind), and the biomedical sector, including stem cells and biomedical equipment. Similarly, Shenzhen's vast infrastructure for transport and storage — key to the institutionalization of zones as nodes in the global economy — augmented its size as the world's fourth-largest container port with a new focus on services and back-office work. Financial services (especially fund and venture capital) and creative industries (especially design) round out Shenzhen's economic profile on the world stage.

Its ultimate value, however, is not measured in GDP (a respectable US$ 25,038 per capita in 2014), exports (more than US$ 245 billion in 2015), or the fifty-three top Chinese companies headquartered in the city alone. Rather, it is in the perception of Shenzhen within China as a world-class city with a mixture of spectacular architecture, 'civilized' citizens, clean streets, and an entrepreneurial spirit in line with the city slogan: "Dare to Become the World's First". In short, Shenzhen wishes to be at the pinnacle of modernity. The modernist dream of the city as the ultimately rational, civilizing force in human development is the other legacy of the zone, one as important as its origins in the postwar export economy. This modernist fantasy comes from a long tradition in (mostly Western) philosophy that Stephen Toulmin characterizes as the dream of Cosmopolis: a rationally ordered society where nature and society fit into precise categories and interact productively according to an unerring logic. The modernist-planned city was thought to give rise to this ordered society and has a long history of seeing the fresh start as its essential ingredient, from American utopian communes in the nineteenth century to the Soviet total planning cities in the twentieth century to contemporary gated communities today.

This is the fantasy of the ideal modernist city as a clean slate, a tabula rasa. The fantasy of the perfect city as a tabula rasa sits deep within Shenzhen, which seems to take to heart the playwright and poet Bertolt Brecht's exhortation in his 1926 *Handbook for City Dwellers* to "erase the traces!". Invariably, Shenzhen is presented in media, promotional materials, and conversation as a city with no history, arising from a proverbial small fishing village or, somewhat more accurately, a small border town. Its historical predecessors, Xin'an (which encompassed both present-day Hong Kong and Shenzhen) and Bao'an counties, become mythologized and temporalized. Its former villages, still physically and psychologically present as traces of a rural past turned urban anomaly, disappear in official representations of the city.

This elision of the past is, in part, what enables Shenzhen to present itself as a unique space that can redeem the past precisely because it is unencumbered by it. Redemption occurs through a focus on the present where, in the words of the city's popular slogans, "practical work brings prosperity" and "time is money, efficiency is life". This emphasis on the pragmatic application of grit and entrepreneurial spirit not only redeems the 'lost' decades of the Cultural Revolution but also helps settle the larger score of being subjected to colonialism. During the city's thirtieth anniversary, for example, a common catchphrase touted how Shenzhen accomplished in thirty years what it took Western society three hundred years to achieve. This is the heroic, even miraculous Shenzhen, which former Chinese President Hu Jintao referred to as "a miracle in the world's history of industrialization, urbanization and modernization".

For those who are familiar with the more rhetorical aspects of the book *Delirious New York,* it will not be difficult to conflate the conditions described by Koolhaas about the genesis of New York with the recent steps by Shenzhen accurately described by Bach above (2017a). For the same reason, it is crucial to grasp the complex and contradictory nature of this scenario in order to understand why Shenzhen is an ideal city to inspire today's dialogue surrounding the relationship between habitants and context. We could say that Shenzhen will be for the twenty-first century what New York represented for the previous one (Figure 1).

Perspectives from Urban Architecture

According to Pérez-Gómez (2016), for many years the (European) city was designed to include a variety of complex atmospheres within its urban fabric, accommodating all human senses as well as targeting the use of diverse public actions. These moods were created to either be apparent to the city's inhabitants or to fade within the backdrop of its activities. From the eighteenth century onwards, the search for increased hygiene within the cities' fabrics led to several changes that oc curred at various speeds and that created the urban context that we currently experience today. These changes occurred alongside the end of the *Ancien Régime* and the creation of the modern nation-states and led to a lack of fundamental qualitative nation-states and led to a lack of fundamental qualitative elements within the urban context. These omissions provided a perception of the city that by comparison was similar to the one perceived from the geometric emptiness that derives from Cartesian coordinates. In the words of Pérez-Gómez Pierre Patte was perhaps the first late-eighteenth century French writer to conceptualize the city in terms of circulation, a metaphor that soon became dominant among planners and that remains

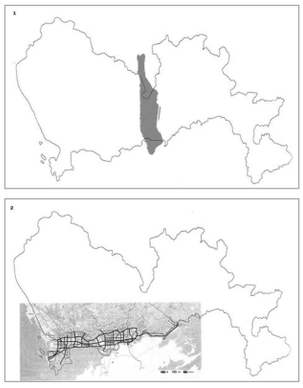

Figure 1. Comparison between Manhattan and SEZ (1); SEZ traffic plan redefined with INFRAREDO© (2) to emphasize the 'city as infrastructure' (Beijing China Academy of Planning, 1985).Adapted from Chuihua, Inaba, and Koolhaas. Great Leap Forward (2001).

unquestioned even today as we think of the metropolis in terms of flux and networks, linking institutional, commercial, and private spaces. While the city had been understood up until this point as a hierarchical assemblage of places for focal action — traditionally, political and religious activities and rituals, and, in the eighteenth century, social and theatrical public functions — Patte believe that better cities called for different priorities, namely and efficient infrastructure for the circulation of goods, vehicles, people, air, and water. […]

Nowadays, even more enlightened planners who argue on behalf of pedestrian cities and struggle to eliminate cars from public spaces tend to use purely quantitative methods and data to further their cause. Such objectives certainly improve the quality of life in places like Copenhagen or Manhattan, for example, but they leave the premises themselves unaltered (2016, p.13-15).

In the past years, new approaches to urban planning have emerged. These are typically tied to the concept of the 'smart city' and 'smart mobility'. Despite contributing to the "Great Leap Forward" (Chuihua et al., 2001) of many metropolises all around the world, these approaches are often accused of producing anonymous and impersonal *urbanscapes.* Efficiency and performance seem to be the only values of the smart approach, which tends to neglect the sociological and psychological aspects of the urban environment. This is mainly because, in order to be processed and become part of smart architecture and design, quantifiable information is needed to capture the underlying effects.

Simultaneously, a humanist and subjective vision of the modern urban arrangement process has been carried out since the second half of the twentieth century. *The Image of the City* (1960) written by Kevin Lynch is a systematic investigation of a metropolis intended for the first time as a personal mental representation; a visual city that beyond its many functions, is seen, remembered, and transformed into a meaningful imaginary.

Environmental images are the result of a two-way process between the environment, which suggests distinctions and relations, and the observer, who, with great adaptability and in the light of this own purposes, selects, organizes, and endows with meaning what he sees (Lynch, 1960, p. 6).

Lynch's view was accepted by Sartogo in *Roma Interrotta* (2014), when a group of twelve well-known — mainly post-modern — architects were asked to draw their own map by reinterpreting a quadrant of the Nolli plan. Among the guests, Aldo Rossi had been developing his theory of a biographical interdependence between city and personal or collective symbolism for years. This is explored, for example, in *Architettura della Città* (1966) and *Città Analoga* (1976). The uniting thread among the aforementioned projects is a common attempt to scientifically examine what has been empirically foreseen for a long time.

Moreover, technology and big data analysis have helped address the aforementioned dichotomy in the field of architecture. Decades of transdisciplinary studies, which involved environmental psychology, human geography, philosophy, cognitive studies, neuroscience, aesthetics —just to name a few— have increased awareness of the importance of introducing the subject's experience of space into the design process (Gregory, 2018).

Eye-tracking in Architecture and Urban research

The adoption of technological instruments, such as eye-tracking devices (i.e. capturing the movement of the eye) to measure human responses to architecture is not new. However, the number of architectural studies that adopted eye-tracking to capture the human gaze and fixation of the built environment is limited compared to the impact this technology has had on usability and reading studies (Poole & Ball, 2006; Duchowski, 2009; Holmqvist et al., 2011). Importantly, despite being a recent and growing area of research, the suitability of eye-tracking to studying the visual perception of the built environment and landscape has been established (Dupont et al., 2013; Hollander et al. 2019; Junker & Nollen, 2019; Sussman & Hollander, 2015). Before introducing the landmark studies that provided evidence of the suitability of eye-tracking in landscape, architecture, and design, a brief account of the foundations and advancement of eye-tracking from psychology to other domains is provided. The foundation of eye-tracking research in early psychological studies is based on eye movement. Importantly, as eye movement was related to visual perception and attentional processes, it could be used as an objective assessment of people's observation of scenes and objects (Bojko, 2013; Horsley et al., 2013; Nielsen & Pemice, 2010).

Subsequently, as researchers settled on eye-movement measures (gaze, fixation, and saccade), eye-tracking approaches expanded to other domains of interest (for a review see Holmqvist et al., 2011; Richardson, 2004).

Eye-tracking studies in architecture can be differentiated based on the area of its application in landscape, design, and architecture, as well as on the use of technological instruments. For example, static or mobile applications of eye-tracking or in conjunction with other apparatuses (e.g. EEG). Lisinka-Kusnierz (2020) reports a series of studies that use static eye-tracking to understand the history of architecture and historical buildings. Results from these studies have shown planners the benefits of heritage protection based on eye-tracking in static settings within historical buildings (Linsaka-Kusnierz & Krupa, 2018).

Interestingly, the eye-movement responses collected among these studies reveal the potential of eye-tracking technology for capturing the different aspects of human visual perception. In Rusnak et al. (2018) for example, depth of perception was assessed from the interiors of a Gothic church by focusing on people's change in interest as a function of the depth and height of the interior. Further areas of application for static eye-tracking have developed since then in both landscape and urban design. Static eye-tracking technology is typically applied in laboratory settings as testing occurs in controlled conditions, which improves the validity of the construct. However, this comes at

the expense of ecological validity. For example, measures of fixation have been proven to correlate with subject preferential parts of photographs, suggesting that information processing occurs as a function of the eye's 'fixation time' (Noland et al., 2017; Birmingham & Kingstone, 2009; Glaholt et al., 2009). Particularly important for architecture in general and landscape architecture in particular is the ability to map the spatial-visual properties of a landscape. A recent account, however, emphasized that there is yet little awareness of the methods available for mapping landscape spaces (Liu & Nijhuis, 2020). For example, one of the only studies that used eye-tracking to assess landscape design (Liu & Nijhuis, 2020) was conducted in Vondelpark (a known park in the Netherlands).

Another example is Traditional Neighborhood Design (TND), adopted as an objective principle of design. By using eye-tracking, visual preference surveys were conducted to elicit positive or negative human responses to urban characteristics. To assess the impact of urban design characteristics, for example, Hollander et al. (2020) report results from Noland et al.'s (2017) study of human responses, which revealed that TNDs have a significant quantitative effect on positive responses. A further body of knowledge drawn from psychological research investigated the influence that spatial cognition has on the experience of places (Robinson & Pallasmaa, 2015; Zeisel et al., 2003; Wells et al., 2007; see Sussman & Hollander, 2015 for an effect of the built environment on human anxiety). Recently, Hollander et al. (2020) emphasized the gap between understanding eye moment in relation to the built environment. Therefore, the influence of a place's urban characteristics on attention and meditation (original italics) was investigated with regard to the pedestrian experience (Hollander et al., 2020).

For the purpose of the present research, it is important to note that despite the growing interest in mobile eye-tracking to assess architectural work, this area of study is less developed within the field of urban architecture. A number of studies have proven the suitability of eye-tracking using mobile devices to assess the impact of urban design. Importantly, positive reactions to the urban environment were collected (Hollander et al., 2019; Zou & Ergan, 2018). Moreover, only one study to date used a long-term experiment in an open urban environment and collected behavioral responses using eye-tracking, showing the implications for life improvement (Ehmke & Wilson, 2007). Therefore, only a limited group of studies previously pursued the investigation of the relationship between urban architecture and eye movements together with focus measures.

With the advancement of eye-tracking technology (e.g. lightweight eye-tracking glasses) it is possible to make up for the lack of studies using outdoor eye-tracking (Uttley, Simpson & Qasem, 2018). Conducting studies in real-world everyday scenarios enhances the representativity of the stimuli environment by placing participants in actual urban settings. For example, as noted in one of the few eye-tracking studies carried out in outdoor urban settings, Simpson et al. (2019) found that gaze patterns are likely to differ between laboratory conditions and natural environments (Foulsham et al., 2011).

Framework: Mobile Eye-Tracking and Urban Villages

The proposed framework is an attempt to address the gap between urban planning and people's needs and expectation from the urban environment.

Although the concept has been explored before (Lynch, 1960; Rossi 1976; Sartogo, 1978), thanks to new technology, architects and planners will be able to develop a more accurate map by empirically quantifying and categorizing architectural elements in association with abstract values like 'appreciation' and 'interest'. Buildings, intersections, parks, and streets will be enriched with layers regarding their usage and information processing data. However, while architects' data collection methods are usually based on documenting, interviewing, historical studies, and cultural references, this study introduces eye-tracking as a new technological instrument (although already established in psychological sciences, neuroscience, and design) for tailored 'open' urban-scale projects. Moreover, future developments of this framework propose to apply eye-tracking to process people's behavior in the cityscape — delivering an authentic perspective in terms of levels of interest and attention — to better understand their needs and enhance architects' ability to respond to it.

By collecting data regarding people's visual perception and their behavior in the urban environment, the goal is to overlay the urban identity of a place on the traditional urban planning layers. Furthermore, introducing numerous everyday people into the urban design process is now possible thanks to the use of technology and the conversion of data into a readable, quantifiable visual outcome.

Feasibility study

Our research began with the following question: how can the urban environment affect pedestrians' visual perceptions, behaviors, and attitudes to further improve the urban design outcome and process?

We used a visual preference survey to investigate people's gaze experience using mobile eye-tracking technology. Accordingly, an observational study was conducted introducing two architectural conditions, namely: sectioned areas and walking lines. Eye-tracking recorded participants' eye-movement metrics: number of fixations (number of times an object was observed), duration of fixation (the amount of time the object was observed), and sequence of fixation (the order in which the observer looked at the objects around him). These objective statistics, with minimum interference by the conductors, are anticipated to capture participants' positive and negative experiences of the city. The data collection phase was completed within one week, while data processing and the elaboration of the visual output required two weeks.

After consenting to the use of their personal data, ten students from Shenzhen University were involved in the feasibility study. All participants were of the same age to guarantee the collection of comparable data. Among the participants, half were male and half were female and half were local and half non-local to prevent the possibility of a biocultural influence.

Sectioned Areas

'Living Shenzhen' was conducted in five out of more than three hundred villages still present in Shenzhen. The proposed feasibility study was first conducted in Futian, one of the main districts of Shenzhen and one of the city's fastest-growing areas. The selected areas were all chosen for their unique characteristics within the formal city. Given their sharp contrast in terms of scale and urban environment, Shenzhen's urban villages seemed particularly suitable for this feasibility study.

By sectioning the areas of the district, the aim is to explore how participants' visual perceptions of the city change when walking the edge between two morphologically different parts of the metropolis: the spontaneous urban villages and the formal fabric of the planned city. Shangsha village offers a snapshot of the widespread phenomenon of the demolition and reconstruction of the urban fabric. The original villagers have cooperated with emerging Chinese real estate developers to replace old buildings with better-quality apartment complexes. An ongoing debate on the transformation process involves the opposing hypotheses of public administrations, who support destruction-reconstruction processes, and researchers and enlightened communities, who promote conservation and regeneration attempts.

The topic of public space for social outdoor aggregation is important for Chinese culture. For property speculation reasons, mature villages are usually made up of 'pencil' buildings, which stand six to eight floors high with a rectangular plan of 100 square meters, separated by one or two meter-large streets, and lacking common spaces to bring people together (Urbano, 2015). Despite being a 'pencil building', Shixia presents squares, sports facilities, a river walk, and an ancient temple, all widely used by local people. This can be viewed as one of the first institutional attempts to offer the villages an alternative to demolition. The area has experienced gentrification and is now well-known for its international nightlife and iconic colored rooftops, where white-collar workers live in rental apartments.

The difference between Shuiwei and its neighboring village, now under an ongoing demolition, is stunning. Another important element involved is its nearby park, one of the biggest in Shenzhen. The neighborhood is now one of the most important city centers in the country because of the dynamism of new skyscrapers integrating with the existing small buildings.

Walking Lines

Though planning still remains car-oriented, over the last 70 years, growing attention has been paid toward the role of pedestrians in shaping the city. Since the post-modernist era, walkability has been identified as a crucial component of an efficient, equitable, sustainable, and livable community (Lo, 2009). Studies in this field address their investigation beyond mere 'walking distance' planning: great importance is given to understanding how urban design affects pedestrian perceptions, behaviors, and attitudes (Mehta, 2008). The current emphasis on walking as a health-related activity (Adkins et al., 2012) has brought an old interest in the sensorial qualities, such as those mentioned in Lynch (1960), Bacon (1967), Bosselmann (1998), and Isaacs (2000), back into vogue. This framework proposes a criterion to capture influences on pedestrians' walking behaviors by collecting data with eye-tracking technology. For example, walkability was operationalized in Moudon et al. (2006). In the present study, 'walking lines' are proposed separately from 'area' (considered in this research as a separate condition). Accordingly, participants were provided with origin (A) and destination (B) and allowed to explore the route freely. Participants with complementary characteristics walked in pairs to their assigned origin and destination route. They were asked to walk

Figure 2. Sectioned areas of the Futian District. Frame took from the Video presented at the exhibition 'Living Shenzhen' Bi-City Biennale of Urbanism/Architecture (UABB) of Shenzhen-Hong Kong 2019-2020 curated by Carlo Ratti.

freely for one hour (according to the battery duration) within a square area (1 km for 1 km). The starting point (A) and endpoint (B) provided transition areas between urban villages and the rest of the city. A and B were inverted for each of the two volunteers. While participants walked the lines of the transition areas, a drone camera filmed the walking lines by flying above the starting and arrival point.

Technology

While walking through the city, participants wore a pair of eye-tracking glasses produced by Tobii and supplied by Psytech, a local tech supplier based in Shanghai, and recruited from Shenzhen University. The glasses recorded simultaneously with a traditional video camera placed over the nose and a special device that captures the pupil's movement while a table instantly registered all of the collected data. The collected data was then converted back into the original video (see Figure, 4 a, b) along with a heat map with transparent background, a visual output elaborated by software specifically programmed for this experiment by Shenzhen University and the Senseable City Lab at MIT.

Results

The overall results from this study show that the distribution of the gaze point appeared with significantly more frequency and for the longest duration in the top zone in the middle and the middle zone. Also, significant but with less frequency and duration, fixation points appeared in the top-right and bottom-middle zone. Ultimately, the gaze points appear least at the bottom-left zone and bottom-right zone. However, the distribution of total fixation duration and fixation count was non-signif-

icantInterestingly, these results appear in contrast with people's normal gaze patterns, as people usually first gaze straight and above and then gaze below and top right; moreover, lower left and lower right are rarer gaze points. The results show that the urban conditions in which this study was conducted did have an influence on participants' gaze experience. However, one limitation of this design was that we were unable to assess the actual experience of participants.

Discussion

The feasibility study presented in this paper adopted an eye-tracking method within two architectural conditions to explore participants' responses with minimum interference by the researchers. The aim was to capture how moving across the varying urban fabric (formal to spontaneous urban villages) affected participants' attention. However, several critical issues that were encountered in conducting the study are important to emphasize for the consideration of future studies. In particular, the hardware used to support the eye-tracking data collection risks producing noise in the data when exposed to direct sunlight. Therefore, there is considerable room for improvement with regard to the reliability of outdoor eye reading. Moreover, it is difficult to perform comparisons with similar research given the nature of the observational design of the conducted study,

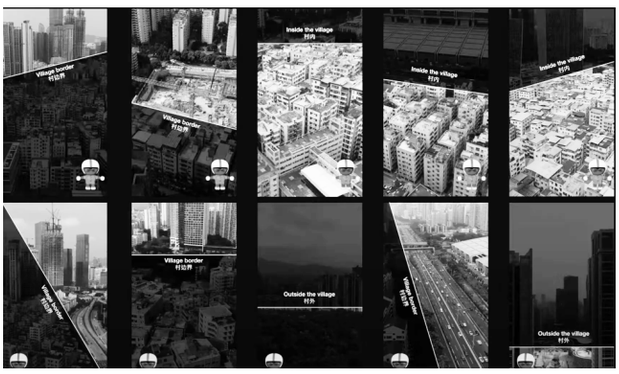

Figure 3. Visual of walking lines of Futian District. Frame taken from the Video Presented at the exhibition 'Living Shenzhen' Bi-City Biennale of. Urbanism/Architecture (UABB) of Shenzhen-Hong Kong 2019-2020 curated by Carlo Ratti.

Figure 4a. Visual output of the gaze/fixation line and target. Frame taken from the Video presented at the 'Living Shenzhen' presented in occasion of the Bi-City Biennale of Urbanism/Architecture (UABB) of Shenzhen-Hong Kong 2019-2020 curated by Carlo Ratti.

Figure 4b. Visual output of the overlapped heatmap. Frame taken from the Video presented at the 'Living Shenzhen' presented in occasion of the Bi-City Biennale of Urbanism/Architecture (UABB) of Shenzhen-Hong Kong 2019-2020 curated by Carlo Ratti.

as in future research several parameters may change. A further critical issue is the time required for data collection, which may vary depending on the characteristics of the area selected and the operationalization of the framework (e.g. dimension of the area, walking distance) and on the quality and specification of the hardware used (e.g. battery duration).

In conclusion, the choice to utilize mobile eye-tracking technology is appropriate for investigating gaze experience by recording people's eye movements in natural settings, as shown from the early literature on this method (Hollander et al., 2019; Junker et al., 2018; Junker & Nollen, 2018; Uttley et al., 2018). Future research should also address the potential ethical challenges of this methodology.

Conclusion

This research project intended to propose a framework with two main outcomes: a method and a map. A dual-faced methodology was used to represent the critical areas of the city of Shenzhen, which is the first city to be analyzed in this way. In this parallel map, the urban reality and the individual perceptive experience dwell in parataxis as in the disjointed dual vision of Aldo Rossi's La città analoga (1976). With further testing in the future, this methodology could act as a template to apply in different urban locations. Moreover, the method proposed in this framework is intended to benefit professionals as an innovative tool for urbanscape planning. For example, via local observation forming an overlay of multiple personal perspectives on the planning process ensuring a fitted, well-thought urban environment for urban planners and stakeholders in the city such as businesses and citizens.

The main component of the described framework is the experimental use of eye-tracking glasses. Eye-tracking recordings were translated into numeric data and then into visual outcomes that can provide a different view of the built environment and might facilitate better communication between daily local life and city planners, who currently have limited mechanisms for urban analysis.

The research assumes the usage of data collection methods for the city and its architecture. The use of smart glasses in a

natural urban environment should be further investigated to simultaneously capture the user's vision combined with geolocation and other physiological information (e.g. heartbeat, skin conductance response). A further possible future development is the design of a platform that brings direct and indirect benefit to all those involved in the process, both as a public instrument to oversee territorial transformations and as an informative open source about city users' experiences.

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