

## Article

# Public Perceptions of Resilient Design Characteristics in Urban Form

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**Abstract:** Resilient design, as a strategy to address various disruptions and pressures, remains poorly understood among the public, which hinders its effectiveness. This study aims to explore how physical elements in urban form, environmental stimuli, and individual attributes influence public perception of resilient design characteristics. A video questionnaire survey was conducted to investigate these perceptions. Results indicate that physical elements—such as road signs, social service facilities, road infrastructure, accessibility to the center, accessible green spaces, diversified activity areas, and disability facilities—negatively impact public perception of resilient design. Conversely, environmental stimuli, including fast/slow, qualitative/quantitative, and short-term changes, positively influence these perceptions. Additionally, the findings reveal that older individuals, those with lower levels of education, and individuals who have had contact with the area for less than three years exhibit weaker perceptions of resilient design characteristics. The study proposes strategies for optimizing resilient design from the perspectives of physical elements and environmental stimuli, while also recommending that future research focus on groups with limited perceptions of resilient design characteristics.

**Keywords:** resilient design characteristics; perception; urban form; physical elements; environmental stimuli; individual attributes



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## 1. Introduction

Urban public space plays a vital role in people's lives and provides space for expressing personal and cultural diversity. However, the lack of open public spaces is a common phenomenon. According to the Economic and Social Council [1], the data from 610 cities in 95 countries show that the share of land allocated to streets and open spaces averaged only approximately 16%. In addition, the expansion of urbanization, coupled with an influx of immigrants, has led to high population densities in urban areas, exacerbating congestion issues, which limits the public's activities in urban public spaces [2]. Furthermore, the heightened population density and complex cultural background have intensified conflicts in spatial utilization. This case is evidenced by uncivilized behaviors such as vandalism and monopoly of space, including conflicts between different types of activity spaces and affected groups (e.g., pedestrians and cyclists) [3]. In this regard, resilient design can mitigate the contradiction in using limited space and enhance space utilization efficiency.

The Resilient Design Institute [4] defined resilient design as the capacity to adapt to changing conditions and maintain or regain functionality and vitality in the face of stress or disturbance. For example, population growth extends to the breaking point of urban infrastructure and service capacity, while environmental pressures change people's lifestyles,

alone with changing population preferences that exacerbate urban stress [5]. Previous research noted that resilient design comprises seven characteristics that can be applied to physical elements. These characteristics are robustness, adaptability, efficiency, diversity, connectivity, redundancy, and modularity. Robustness is ensured through updated building standards and the decentralization of key infrastructure, enhancing its capacity to resist damage and maintain functionality when facing potential risks such as natural disasters and extreme weather. This improves the system's ability to adapt and remain resilient under pressure [6]. The public perceives the reliability and durability of infrastructure by observing its structural strength and quality, which deepens their understanding of the importance of resilient design. Adaptive design, by incorporating flexible infrastructure, such as multi-level street layouts, strengthens the system's responsiveness to environmental changes and fosters public interaction, thus enhancing its ability to meet future demands and challenges [7]. The public can evaluate the flexibility and adaptability of infrastructure through these design features.

Efficiency is reflected in the optimization of resource allocation, flexible adjustment of functions, and reduction of system loads, directly enhancing the city's capacity to respond to challenges. Through high-density design and mixed-use spaces, the public understands how the maximization of resources and provision of multifunctional services contribute to the city's resilience [8]. Diversity in design, achieved through spatial and functional variety, enhances the system's ability to adapt to change [9]. By observing the distribution of functional areas and the combination of different spatial uses, the public perceives how this diversity strengthens the resilience of the urban system.

Connectivity, by offering multiple path options, improves response times and enhances the flow of resources and social interactions [10], while redundancy, through the provision of backup capacity and alternative options, disperses risk, ensuring the system continues to operate even when part of it fails [11]. The public recognizes how these physical features contribute to enhancing the resilience of the urban system. Modular design, through standardization and repeatability, increases the system's flexibility, enabling infrastructure to quickly adapt to change and ensuring more efficient maintenance and upgrades [12]. Through these features, the public gains a comprehensive understanding of the flexibility of resilient design, forming an overall evaluation of its effectiveness.

Despite the importance of resilient design strategies in urban planning, public awareness of their characteristics remains unclear, which affects the effectiveness of these strategies. For example, resilient design strategies have long faced adverse reactions, where the upgraded infrastructure was no better than the non-upgraded one over time. In some cases, even the improved infrastructure has shown signs of deterioration [13]. Therefore, this study aims to assist planners in developing highly effective, resilient urban design strategies that the public understands, while addressing contradictory space use.

The research questions for this study are as follows:

1. How does the public perceive the resilient design characteristics of physical elements in urban form?
2. What impact do environmental stimuli have on the public's perception of resilient design characteristics?
3. How do individual attributes influence the public's perception of resilient design characteristics?

The specific objectives are to: (1) explore the public's perceptions on resilient design characteristics of physical elements in urban form; (2) understand the impact of environmental stimuli on the perception of resilient design characteristics; and (3) identify how individual attributes affect the perception of resilient design characteristics.

Previous studies have shown that the public primarily perceives their environment through visual cues. Approximately 80% of public perception is derived from visual cues, and spatial visual attributes such as color, texture, density, layout, scale, style, and appearance form the foundation of this perception [14–16]. These elements interact to evoke various perceptions of space, thereby creating different impressions [17].

When perceiving resilient design, the public primarily identifies and understands it through two types of visual cues. First, the visual effects generated by the arrangement and distribution of physical elements in space, such as balance, symmetry, simplicity, scale, proportion, size, shape, etc. [18], not only influence the public's emotions and experiences but also play a significant role in shaping their overall perception and evaluation of the environment [19–21]. Second, the dynamic changes of physical elements in space, as visual stimuli, directly affect public perception and behavior, helping them to better understand the flexibility and adaptability of resilient design [22].

Based on previous research, factors influencing perception can be summarized into three perspectives: physical elements, individual attributes, and environmental stimuli. The landscape perception theory of Zube, Sell, and Taylor [23] mentioned that the perception process is influenced by two main factors: “human” and “landscape properties”, where “landscape properties” include tangible physical elements.

Previous research indicated that physical elements with resilient design characteristics include physical infrastructure and spatial structures [24]. In addition, the complexity and dynamics of urban forms influence human activities and urban development, playing a vital role in achieving urban resilience [12]. The existing literature claimed that urban form comprises three dimensions: density, location, and use pattern [8,12]. Some resilient design characteristics in urban form have positive effects on urban resilience. For example, highly compact and evenly distributed infrastructure and spatial structures, including mixed-use patterns, can mitigate contradictions in space use [15]. Therefore, this study proposes to investigate the resilient design characteristics of urban spatial structures and infrastructure across these three dimensions.

In landscape perception theory, “human” refers to individual attributes, such as age, gender, education level, and experience. These attributes affect how people perceive and understand the landscape. Different age groups may provide different perceptions and preferences; for example, young people are highly willing to convey perceptual information, whereas gender can lead to distinct perceptual patterns [25]. In addition, individuals with high levels of education may be greatly aware of the variations within landscapes [26].

Ribeiro [27] defined experience as the foundation where individual perceptions are formed, with perception being the outcome of interactions among individual experiences, the physical attributes of perceptual scenes, and the context. Furthermore, given the differences in individuals' experiences, perceptions are diverse and evolve [28], highlighting the profound impact of experience on perception formation.

According to Gibson [29], the theory of direct perception indicates that perception is a direct product of human contact with the outside world, which is primarily influenced by visual factors. Therefore, differences in people's perception are caused by the change in visual factors within the environment [30]. In other words, the dynamic changes of physical elements can be considered a part of environmental stimuli. The descriptions of changes in visual aspects in the previous literature can be summarized into 10 types: slow, fast, sudden, regular, long-term, short-term, small, large, qualitative, and quantitative changes.

Antrop [31] claimed that the nature of the component or feature should be considered when studying change, including the frequency, pace and magnitude of change. For example, some changes occur rapidly, whereas others occur slowly and are often imperceptible. These changes can refer to the movement speed of objects in public spaces, manifested

specifically in the form of rapidly moving or slowly traveling vehicles. However, sudden and regular changes also occur [32]. These changes refer to the frequency of dynamic objects or activities. For instance, the sudden removal or alteration of a particular device or facility can be contrasted with the routine maintenance activities that are conducted regularly. Long- and short-term changes can impact people's evaluations of landscape quality [30]. These changes refer to the duration of dynamic objects or activities, such as the prolonged presence of construction work versus the temporary display of holiday decorations. In addition, the size of changes in visual elements affects the perception outcome [31]. These changes refer to the variations in the volume of dynamic objects, such as the size differences between large and small moving installations within a landscape.

Pablo, Roldán-Martín, and Agar [33] claimed that the magnitude of change can be defined in two parts: quantitative, which refers to the number of areas of change and qualitative, which refers to the differences before and after the change. In this context, these changes pertain to the degree of dynamic objects or activities. For example, this includes variations in the number of infrastructure elements within spatial layouts and the alterations made by certain devices or facilities to the environmental state. Even if an area incurs a significant change in size and magnitude, it represents a quantitative significance rather than a qualitative difference if the significance is low. In other words, the quantity and quality of the scope of changes are disproportionate to the dependencies. Moreover, the impact of large-scale changes can be small, whereas, conversely, even small-scale changes can have significant consequences.

As highlighted in the literature, physical elements, individual attributes, and environmental stimuli are widely recognized as key factors affecting public perception of resilient design. Therefore, this study focuses on these specific factors, considering the following aspects:

Firstly, physical elements, as the core of urban structure, such as infrastructure and spatial structures, directly exhibit the key characteristics of resilient design. For example, through mixed land use, decentralization of critical infrastructure, and the updating and enforcement of building regulations, physical elements enhance the robustness of urban systems [6,34]. Simultaneously, hierarchical street structures, flexible and diverse land use, and the integration of green infrastructure with multiple transportation modes improve the city's adaptability to changes [7,35]. The design of complex, high-density superblocks, compact polycentric development, and the integration of renewable energy sources increase the efficiency of urban energy systems [8,36]. Mixed-use areas, short street blocks, diverse building types and spatial heterogeneity promote diversity in public activities and urban functions [9,37]. Dense intersections, grid street layouts, and various access points enhance the connectivity of urban spaces [10]. By implementing polycentric development, distributed infrastructure, and modular systems, physical elements offer more options for cities, ensuring redundancy when components fail [11,38]. Lastly, standardized modular construction, integration and separation of components, ensure the modularity and flexible scalability of the system [12].

Second, individual attributes, such as age and cultural background, serve as personalized filters in the perception process, as different groups have varying needs and experiences with resilient design, reflecting the diversity and variability in public perception. Lastly, environmental stimuli, as external variables, dynamically influence the public's perception of space and design. Visual changes, in particular, capture public attention and stimulate their perception of urban spaces and design [22]. These specific environmental stimuli affect the public's experience of space in various ways, thereby enhancing their recognition and understanding of the characteristics of resilient design. This awareness further encourages more active public participation in the processes of resilient urban

design and maintenance, ultimately making resilient urban design more effective. These three perspectives provide a multi-layered analytical framework for understanding the factors that influence public perception of resilient design characteristics. Therefore, this study considers physical elements, individual attributes, and environmental stimuli as independent variables, with public perception as the dependent variable. This approach is not only theoretically well-supported but also offers a structured foundation for exploring how these factors shape public perception.

## 2. Materials and Methods

This study focuses on how physical elements, environmental stimuli, and individual attributes influence public perceptions of resilient design characteristics within urban form. First, the study investigates the public's perception of the intensity of resilient design characteristics. Subsequently, the study explores the impact of environmental stimuli on perceptions of resilient design characteristics and identifies differences in individual perceptions of these features. Finally, the study proposes strategies for enhancing resilient design characteristics from the urban form perspective.

### 2.1. Study Area

The selected site should have sufficient resilient design characteristics to measure public perception of resilient design characteristics. In addition, the chosen site should possess the following characteristics: (1) an evolving public space with numerous flexible, informal areas; (2) diverse public spaces reflecting lifestyle diversity and accommodating various interest groups; (3) an open, unrestricted and free public space [39].

The study focuses on Yongqing Fang in the Guangzhou Old Town (see Figure 1). As the capital of Guangdong Province, the city is a first-tier megacity. With the rapid development of urbanization, improving the quality of life in cities is also one of the main goals of urban planning. Once Guangzhou's most prosperous core area, Yongqing Fang declined as the city center relocated. In the past 8 years, the local government has launched an old town revitalization project, which is not only a revitalization of the city but also essential for the livelihood of the people. The reconstruction plan for the area must not only respond to the historical and cultural memory of the local community, but also meet the needs of contemporary development and attract new groups. Considering these complex requirements, resilient design is necessary to resolve these dilemmas.

### 2.2. Survey Instruments

This study used a video questionnaire to explore the public perception of resilient design characteristics in urban form combined with relevant variables. Videos can reflect multiple aspects of the environment, such as visual information, auditory information, static information, and dynamic information [40]. The video questionnaire consisted of 10 video clips shown on public streets in the city and captured the public view of these settings at eye level. Each video should not exceed 30 s in length. The specific filming locations include different types of streets, such as wide streets, narrow streets, layered streets, interconnected streets, intersections, tree-lined streets, grid streets, circular streets, accessible streets, short blocks, multi-center streets, and diverse-edge streets. These locations feature buildings or facilities with various resilient characteristics and mixed land use patterns [8,11,12,34–38].

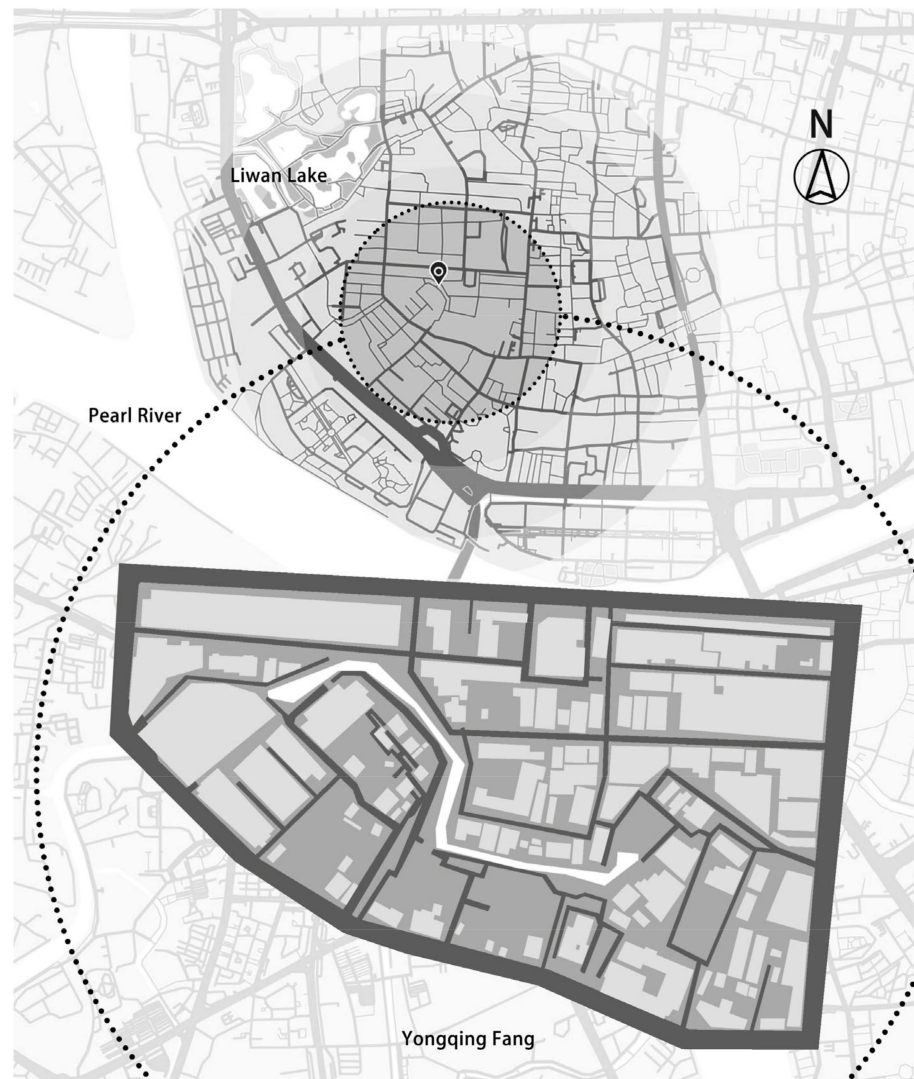


**Figure 1.** Study area: Yongqing Fang, Guangzhou, China.

The 10 video clips each contain distinct environmental stimuli: long-term, short-term, sudden, regular, fast, slow, large, small, quantitative, and qualitative changes (see Figure 2). These video clips were captured in the study area based on the definitions of ten types of environmental stimuli [30–33]. The scene representing long-term change depicts road maintenance at a busy intersection in a public space. The short-term change is characterized by the establishment of a temporary sales and display area in a square. The sudden change is illustrated by a boat unexpectedly entering the center of a calm river. Regular change refers to the routine maintenance of infrastructure. The fast change scene features numerous swiftly moving vehicles, while the slow change illustrates a boat moving gradually along the river. The scene representing large change showcases large art installations that are regularly updated throughout public spaces, whereas the small change depicts several movable art installations and advertisements that change intermittently. The scene of quantitative change illustrates a public space filled with various lighting that evolves over time, while the qualitative change scene describes a cooling mist system installed on the wall of a relatively narrow alley, which operates intermittently to release mist. In the questionnaire, participants were asked to use a five-point Likert scale to rate the intensity of resilient design characteristics in the ten video clip scenes.

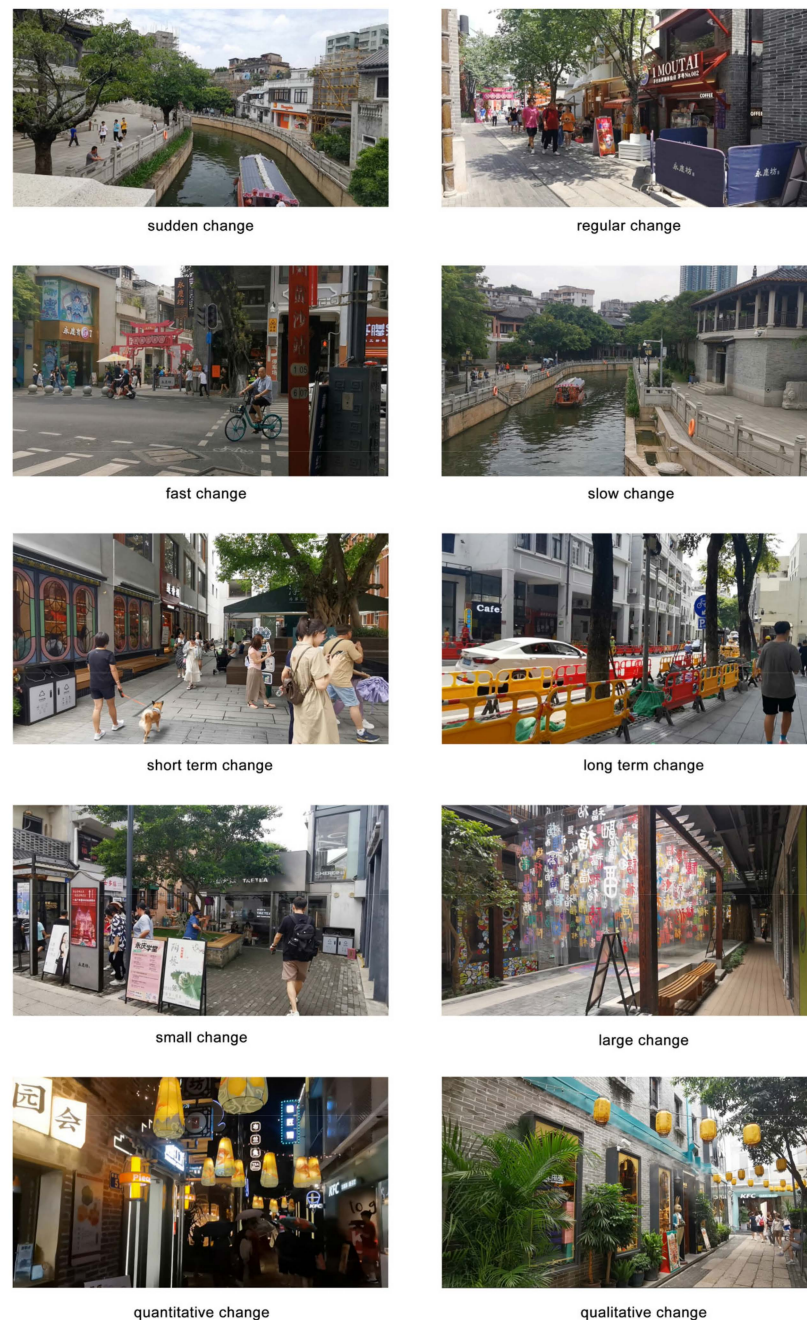


**Figure 2.** Video clips of environmental stimuli.

The questionnaire also included written items to enrich participants' understanding of resilient design characteristics. These items have been modified based on the previous scale for current research objectives [12,15]. These items were rated on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree). Moreover, demographic variables were measured, including gender, age, education, time of contact with the area, and frequency of visits.

This study utilized the Wenjuanxing platform for the survey. A screening mechanism was implemented on the platform, whereby participants selecting certain options were automatically filtered out as not meeting the eligibility criteria. The finalized questionnaire link was distributed through social media channels.

### 2.3. Participants

The survey was conducted online. The target group of this study is people who have visited Yongqing Fang within a year. Considering that this group belongs to the mobile population, determining the sampling frame is not possible. Therefore, this questionnaire survey adopted non-random quota sampling as the sampling method. This study recognized that a bias towards self-selection exists. One way to overcome this bias is to allocate 25% to each quota based on the time of first contact with the region. Based on the formula of Krejcie and Morgan [41] to determine sample size, the total sample size for this survey was 384, where each quota took up 96 samples. In this way, the sample surveyed can at least obtain the impact of different experiences on perception.

All subjects have provided appropriate informed consent and were required to read from the introduction to the purpose of the study before answering the questionnaire. The Research Subject Information and Consent Form and the Research Subject's Material Publication Consent Form are attached. The questionnaire survey can only be conducted after the participants have expressed their consent.

### 2.4. Data Analysis

The survey data were processed in SPSS version 26.0 and AMOS 24.0. First, the study tested the reliability and validity of the scale. The results of the reliability test showed Cronbach's alpha  $> 0.7$ . Therefore, the scale of the survey was considered internally consistent. Given that the scale was adapted from a previous mature scale, exploratory and confirmatory factor analyses were conducted to test the validity of the scale. KMO and Bartlett's test of sphericity are generally used to test structural validity, which are typically considered KMO  $> 0.6$  and Bartlett  $< 0.05$ . According to the results, KMO = 0.97 ( $> 0.6$ ) and Bartlett's test of sphericity  $< 0.05$  meet the requirements for exploratory factor analysis (EFA). The 62 items included in this questionnaire were divided into seven constructs: robustness, adaptability, efficiency, diversity, connectivity, redundancy, and modularity. In the EFA, two items failed the validity test because their loading on any dimension was lower than 0.5. They were considered invalid items and were removed. The remaining items were included in a single construct, and the loading was greater than 0.5. They were deemed valid items and were reserved.

A good set of parameter indices should be used for confirmatory factor analysis, CMIN/DF  $< 3$ , CFI  $> 0.9$  and RMSEA  $< 0.08$ . Although AVE  $\geq 0.5$  is generally required, AVE = 0.4 is acceptable if the composite reliability is greater than 0.6 (Rahman & Al-Emad, 2018). The test results of this questionnaire show that all meet the standard (CMIN/DF = 1.221,  $< 3$ ; CFI = 0.968,  $> 0.9$ ; RMSEA = 0.024,  $< 0.08$ ). This result showed that the model fit the scale well and was valid (see Table 1).

**Table 1.** Results of confirmatory factor analysis.

| Constructs   | Cronbach's Alpha | AVE  | CR   |
|--------------|------------------|------|------|
| Robustness   | 0.86             | 0.51 | 0.86 |
| Adaptability | 0.85             | 0.48 | 0.85 |
| Efficiency   | 0.90             | 0.49 | 0.90 |
| Diversity    | 0.92             | 0.51 | 0.92 |
| Connectivity | 0.92             | 0.52 | 0.92 |
| Redundancy   | 0.89             | 0.45 | 0.89 |
| Modularity   | 0.87             | 0.49 | 0.87 |

The participants' average scores for each construct were calculated once the constructs of the scale were determined. Descriptive statistics were used to present participants' perceptions of resilient design characteristics and the scores of environmental

stimuli on the perceived resilient design characteristics. The Mann–Whitney U test, the Kruskal–Wallis test, pairwise comparisons, the Scheirer–Ray–Hare test, and simple effects were used to compare the differences in the influence of individual attributes on the perceived resilient design characteristics. Moreover, Spearman’s rank correlation analysis was used to determine correlations between individual attributes and perceptions of resilient design characteristics.

### 3. Results

#### 3.1. Demographic Composition of Survey Participants

Table 2 presents the demographic composition of 384 survey participants.

**Table 2.** The demographic composition of survey participants.

| Participant Characteristics                            | Number of Participants | Percentage |
|--------------------------------------------------------|------------------------|------------|
| Gender                                                 |                        |            |
| Male                                                   | 204                    | 53.1       |
| Female                                                 | 180                    | 46.9       |
| Age                                                    |                        |            |
| 18–29                                                  | 134                    | 34.9       |
| 30–39                                                  | 108                    | 28.1       |
| 40–49                                                  | 73                     | 19         |
| 50–65                                                  | 69                     | 18         |
| Education level                                        |                        |            |
| Junior high school education or below                  | 93                     | 24.2       |
| Senior high school or vocational or technical training | 150                    | 39.1       |
| Bachelor’s degree or above                             | 141                    | 36.7       |
| Frequency                                              |                        |            |
| 1 time a week                                          | 98                     | 25.5       |
| Several times a week                                   | 213                    | 55.5       |
| Sometimes                                              | 49                     | 12.8       |
| Had not been there recently                            | 24                     | 6.2        |

#### 3.2. Perception of the Intensity of Resilient Design Characteristics

The mean scores of the seven constructs, namely, robustness, adaptability, efficiency, diversity, connectivity, redundancy, and modularity, were summed and averaged to present the participants’ perceived intensity of the resilient design characteristics (see Table 3). The results show moderate overall intensity of participants’ perception of resilient design characteristics.

**Table 3.** Descriptive statistics of perceived intensity in resilient design characteristics.

| Constructs                                               | Mean   | S.D. |
|----------------------------------------------------------|--------|------|
| Robustness                                               | 3.63   | 0.71 |
| There are robust infrastructures                         | 3.72   | 0.90 |
| The buildings here are made of good materials            | 3.67   | 0.91 |
| The green spaces here are in good condition              | 3.63   | 0.94 |
| The stores here are located in buildings of poor quality | 3.60 * | 0.91 |
| There is mixed-use land                                  | 3.59   | 0.95 |
| The road signs here are well-maintained                  | 3.55   | 0.99 |

Table 3. *Cont.*

| Constructs                                                                              | Mean   | S.D. |
|-----------------------------------------------------------------------------------------|--------|------|
| Connectivity                                                                            | 3.62   | 0.69 |
| Each part of the public space is interconnected                                         | 3.68 * | 0.91 |
| The walking paths here are not cohesive                                                 | 3.68 * | 0.91 |
| Public transportation is provided to this public space                                  | 3.64   | 0.94 |
| This area is too isolated from the rest of the city                                     | 3.64   | 0.87 |
| I feel like I can move freely within the space                                          | 3.62   | 0.89 |
| This public space is well-connected with surrounding buildings, streets, and open space | 3.62   | 0.91 |
| The greenery in this public space is cohesive                                           | 3.61   | 0.95 |
| Entering this public space involves circling round                                      | 3.60 * | 0.94 |
| It is easy to leave this area                                                           | 3.59   | 0.94 |
| Access to the central area of this public space is easy                                 | 3.54   | 0.92 |
| There are numerous roads options to exit the area                                       | 3.54   | 0.94 |
| Efficiency                                                                              | 3.60   | 0.69 |
| The greenery is well-maintained here                                                    | 3.67   | 0.93 |
| The physical environment in the public space can encourage social interaction           | 3.63   | 0.95 |
| Parked cars hinder pedestrian movement                                                  | 3.62 * | 0.93 |
| The sidewalk is separated from the road                                                 | 3.61   | 0.93 |
| Cycling around the public space is easy                                                 | 3.61   | 0.92 |
| Open spaces and built-up areas are well-balanced here                                   | 3.60   | 0.90 |
| Most of the green spaces here are off-limits to the public                              | 3.56 * | 0.96 |
| The refuse collection service here is efficient                                         | 3.56   | 0.94 |
| Cycling in this public space is dangerous                                               | 3.56   | 0.93 |
| Modularity                                                                              | 3.60   | 0.71 |
| The entrance spaces here are well distributed                                           | 3.65   | 0.97 |
| Buildings here are too clustered                                                        | 3.61 * | 0.93 |
| Stores here are not well distributed                                                    | 3.60 * | 0.97 |
| The public space is isolated                                                            | 3.60 * | 0.93 |
| Open spaces are well distributed                                                        | 3.59   | 0.93 |
| Buildings here are detached                                                             | 3.57 * | 0.93 |
| Social service facilities here are unevenly distributed                                 | 3.56 * | 0.99 |
| Adaptability                                                                            | 3.58   | 0.69 |
| There are flexible mix of infrastructures                                               | 3.61   | 0.87 |
| There is a lack of transition space between different areas                             | 3.59 * | 0.95 |
| I do not perceive any disturbing details here                                           | 3.59   | 0.93 |
| The variety of recreational facilities is relevant for different users                  | 3.58   | 0.93 |
| The streets here are wide enough for smooth passage                                     | 3.56   | 0.91 |
| It is well-suited for handicapped people                                                | 3.55   | 0.89 |
| Redundancy                                                                              | 3.58   | 0.65 |
| Parking places and lots are lacking                                                     | 3.65 * | 0.90 |
| Physical facilities meet public needs adequately                                        | 3.65   | 0.91 |
| There is ample green space                                                              | 3.61   | 0.90 |
| There is a good availability of parking spaces                                          | 3.60   | 0.93 |
| Appropriate, adequate, and comfortable seating is available here                        | 3.59   | 0.92 |
| There are plenty of bicycle routes around the public space                              | 3.58   | 0.91 |
| There is ample lighting throughout                                                      | 3.56   | 0.93 |
| There are numerous facilities for sports and physical activities                        | 3.55   | 0.96 |
| There is limited space between buildings                                                | 3.54 * | 0.92 |
| There are plenty of walking paths in the public space                                   | 3.50   | 0.90 |

Table 3. Cont.

| Constructs                                                                                         | Mean   | S.D. |
|----------------------------------------------------------------------------------------------------|--------|------|
| Diversity                                                                                          | 3.57   | 0.71 |
| The lack of meeting places prevents young people from spending their free time in the public space | 3.62 * | 0.94 |
| There are various types of stores                                                                  | 3.61   | 0.91 |
| This public space offers various attractions                                                       | 3.60   | 0.95 |
| Many green areas are disappearing in this public space                                             | 3.58 * | 0.94 |
| I can obtain a great deal of information in this public space                                      | 3.56   | 0.93 |
| There is a variety of green infrastructure                                                         | 3.56   | 0.95 |
| There is diversity in building types in this public space                                          | 3.55   | 0.96 |
| This public space has a variety of diverse visual elements                                         | 3.55   | 0.97 |
| Building details in this public space are well-crafted                                             | 3.55   | 0.95 |
| This public space is characterized by detailed design                                              | 3.53   | 0.96 |
| I am limited in the range of activities I can do here                                              | 3.53 * | 0.96 |

\* Reversed scoring.

### 3.3. Perception of Resilient Design Characteristics Under Changes in Visual Factors

The study found that different degrees and types of environmental stimuli impact public perceptions of resilient design characteristics. The results show that environmental stimuli are presented in fast/slow, qualitative/quantitative, and short-term changes, facilitating a strong perception of resilient design characteristics. However, the public perceives resilient design characteristics poorly when environmental stimuli present large/small, regular/sudden, and long-term changes.

Furthermore, within the same environmental stimuli, only short- and long-term changes demonstrate differences in the impact of the public's perception of resilient design characteristics. Under short-term environmental changes, 29% perceive resilient design characteristics positively, whereas 20% hold negative perceptions. However, in the context of long-term environmental changes, positive perceptions were 11%, whereas negative perceptions were 33%. These results show that resilient design characteristics are easily perceived under short-term environmental changes. No significant differences were observed among the remaining four groups of different types of environmental stimuli (see Figure 3).

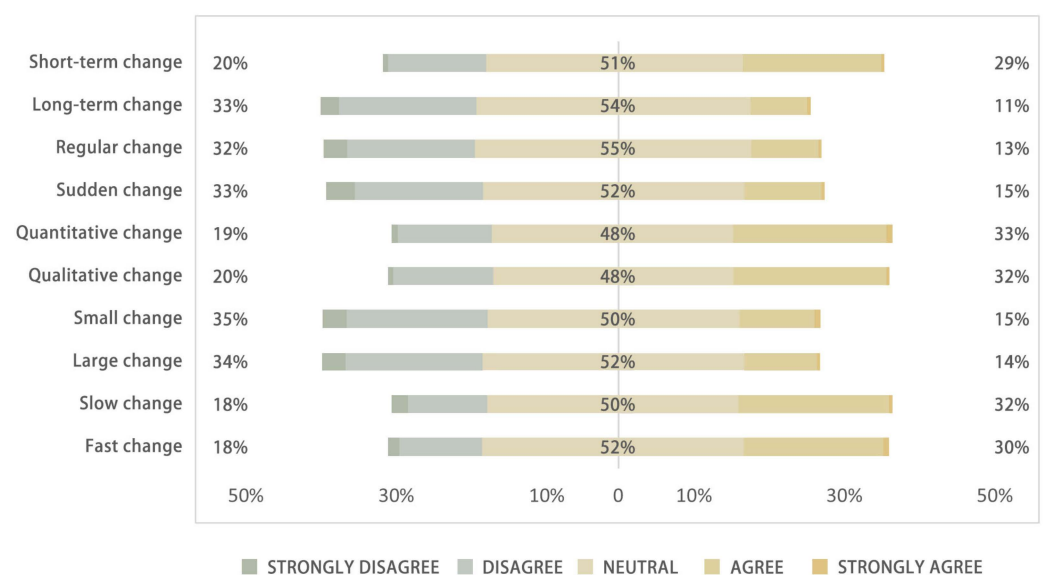


**Figure 3.** Perceptions of stakeholder groups on resilient design characteristics in different magnitudes and types of environmental stimuli.

### 3.4. Perception of Resilient Design Characteristics Based on Individual Attributes

Mann–Whitney U test was conducted to compare the intensity of perception of resilient design characteristics in males and females. No significant effect was observed for gender ( $z = -0.78$ ,  $p = 0.44$ ), despite males ( $M = 196.65$ ) attaining higher scores than females ( $M = 187.80$ ) on the intensity of resilient design characteristics perception.

This study assigned 384 participants to four age groups. Mean ranks were age group 18–29 ( $M = 243.78$ ), 30–39 ( $M = 187.17$ ), 40–49 ( $M = 160.18$ ), and 50–65 ( $M = 135.44$ ). Kruskal–Wallis test was used to compare the influence of age on the perceived intensity of resilient design characteristics. This test indicated that a statistically significant difference of age exists in the perception intensity of resilient design characteristics ( $H(3) = 53.29$ ,  $p < 0.001$ ). Then, pairwise comparisons further revealed significant differences between the age group of 18–29, 30–39, 40–49, and 50–65 years. In addition, a significant difference ( $p < 0.05$ ) was observed between the age groups of 30–39 and 50–65 years. However, no significant differences were found between the age groups of 30–39 and 40–49 years ( $p = 0.65$ ), as well as between the age groups of 40–49 and 50–65 years ( $p = 1.00$ ) (see Figure 4). These findings indicate that younger individuals have a strong perception of resilient design characteristics, followed by middle-aged individuals, whereas older individuals demonstrate a comparatively low perception intensity.

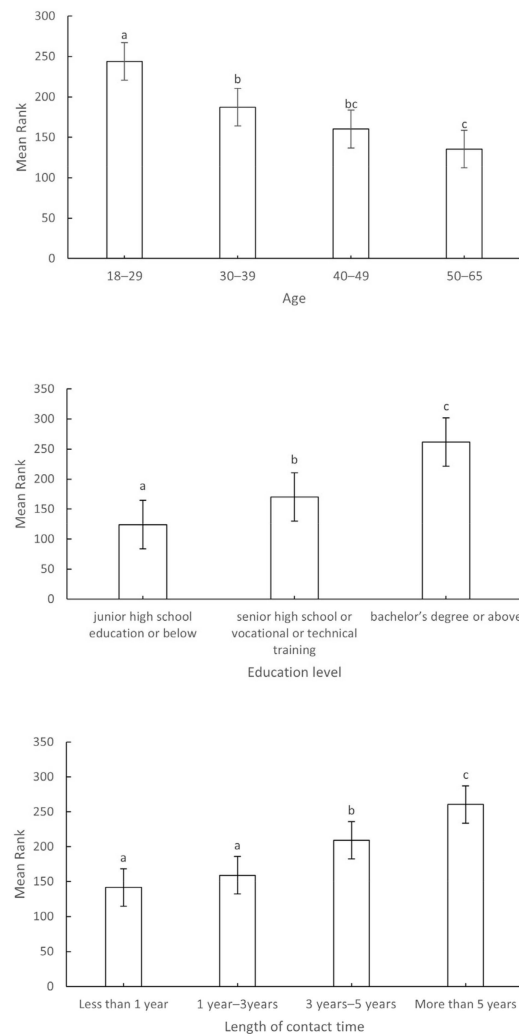


**Figure 4.** Pairwise comparisons of differences across age, education level, and length of contact time. The letters (a–c) marking indicate significant differences among groups. Groups sharing the same letter do not differ significantly, while those with different letters show significant differences ( $p < 0.05$ ).

The participants' education levels in this study were divided into three groups. Mean ranks were junior high school education or below ( $M = 123.98$ ), senior high school or vocational or technical training ( $M = 170.07$ ) and bachelor's degree or above ( $M = 261.56$ ). The study employed the Kruskal–Wallis test to compare the influence of education level on the perception intensity of resilient design characteristics. The results indicated a statistically significant difference in education level on the perception intensity of resilient design features ( $H(2) = 96.17, p < 0.001$ ). Pairwise comparisons further revealed significant differences among all education levels ( $p < 0.05$ ) (see Figure 4). These findings show that highly educated groups strongly perceive resilient design characteristics, followed by those with intermediate education levels. By contrast, individuals with primary education levels demonstrate the lowest perception intensity.

This study divided participants into four groups based on the length of time since their first arrival at Yongqing Fang. Mean ranks were less than 1 year ( $M = 141.46$ ), 1–3 years ( $M = 158.98$ ), 3–5 years ( $M = 209.18$ ), and more than 5 years ( $M = 260.38$ ). The objective is to investigate whether the length of individuals' contact time in a place affects their perception intensity of resilient design characteristics. The study employed the Kruskal–Wallis test to compare the effect of the length of contact time on the intensity of resilient design characteristics perception. The results revealed that a statistically significant difference exists in the length of contact time on intensity of resilient design characteristics perception ( $H(3) = 67.15, p < 0.001$ ). Pairwise comparisons indicated significant differences among all groups ( $p < 0.05$ ), except among groups with a contact time of less than 1 and 1–3 years ( $p = 1.00$ ) (see Figure 4). These findings indicate that longer contact time is associated with strong perceptions of resilient design characteristics, followed by moderate contact time, with the weakest perceptions observed among those with short contact time.

The Kruskal–Wallis test was employed to compare the intensity of perception of resilient design characteristics across visit frequencies. The results indicated that visit frequency had no significant effect on the perception intensity of resilient design characteristics ( $H(3) = 0.67, p = 0.88$ ).

The study employed the Scheirer–Ray–Hare test, which revealed the interaction effects between the following: gender and age ( $H(3, 376) = 1.25, p = 0.74$ ), gender and education level ( $H(2, 378) = 0.48, p = 0.79$ ), gender and contact time ( $H(3, 376) = 0.87, p = 0.83$ ), gender and frequency ( $H(3, 376) = 0.64, p = 0.89$ ), age and education level ( $H(5, 373) = 4.81, p = 0.44$ ), age and frequency ( $H(9, 368) = 3.84, p = 0.92$ ), education level and frequency ( $H(6, 372) = 3.04, p = 0.80$ ), as well as contact time and frequency ( $H(9, 368) = 4.95, p = 0.84$ ). Their interaction effects were not statistically significant.

The study examined the interaction effect of age and contact time on the public's perception of resilient design characteristics. The Scheirer–Ray–Hare test revealed a significant interaction effect between age and contact time ( $H(9, 368) = 82.93, p = 0.00$ ). Simple effects analysis indicated significant differences ( $p < 0.05$ ) between the age groups of 30–39 and 40–49 years, including between the age groups of 30–39 and 50–65 years, when the contact time was less than 1 year. As age increases, the strength of the public's perception of resilient design characteristics increases. Moreover, significant differences ( $p < 0.05$ ) in the contact time were observed between the age groups of 18–29 and 40–49 years, 18–29 and 50–65 years, 30–39 and 40–49 years, as well as 30–39 and 50–65 years, when the contact time ranged from 3 to 5 years. Similarly, when the contact time exceeded 5 years, significant differences ( $p < 0.05$ ) in the perception of resilient design characteristics were observed between the age groups of 18–29 and 30–39, 40–49, and 50–65 years (see Figure 5). These findings show that when the contact time exceeds 3 years, the younger groups have a stronger perception of resilient design characteristics than middle-aged and elderly groups.

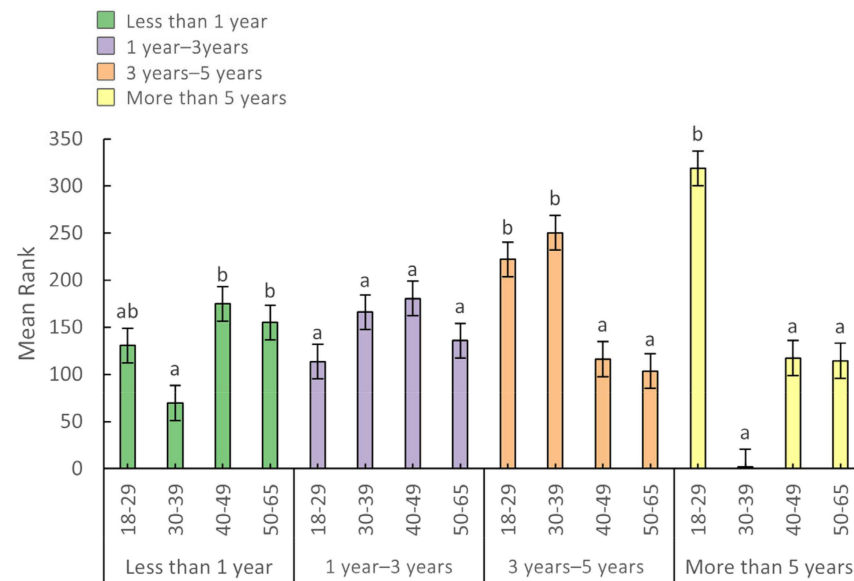


**Figure 5.** Simple effects results of differences between age within different contact time. The letters (a,b) indicate significant differences among groups. Groups sharing the same letter do not exhibit significant differences, whereas groups with different letters show significant differences ( $p < 0.05$ ).

The simple effects analysis revealed that no significant difference ( $p = 0.99$ ) exists in the contact time between less than 1 and 1–3 years for the age group of 18–29 years, whereas significant differences ( $p < 0.05$ ) were observed among other contact time groups. In the age group of 30–39 years, no significant differences were found between contact time less than 1 and over 5 years ( $p = 0.97$ ), as well as between contact time of 1–3 and over 5 years ( $p = 0.28$ ). This result is primarily because of the small sample size of the 30–39 years age group with a contact time of more than 5 years. Significant differences ( $p < 0.05$ ) were observed among other contact time groups. However, no significant differences ( $p > 0.05$ ) were found in contact time between the 40–49 and 50–65 years age groups (see Figure 6). These results indicate that, in younger age groups, long contact time corresponds to strong perceptions of resilient design characteristics.

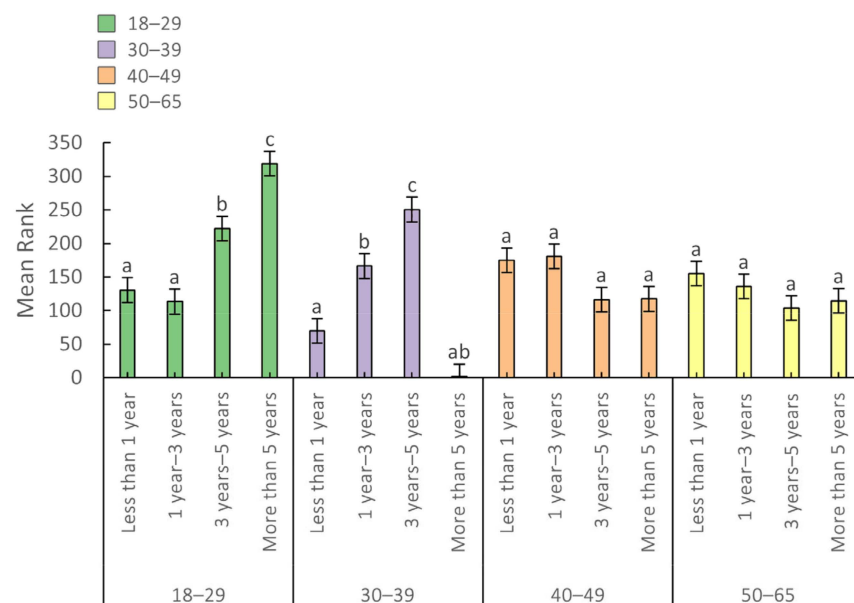


**Figure 6.** Simple effects results of differences between contact time within different age. The letters (a–c) marking indicate significant differences among groups. Groups sharing the same letter do not differ significantly, while those with different letters show significant differences ( $p < 0.05$ ).

The study analyzed the interactive effects of education level and contact time on the public's perception of resilient design characteristics. The Scheirer–Ray–Hare test results revealed a significant interaction between education level and contact time ( $H(6, 372) = 54.47$ ,  $p = 0.00$ ). Simple effects analysis indicated significant differences ( $p < 0.05$ ) between the groups with junior high school education or below and those with high school or vocational training education when the contact time was between 1 and 3 years. Similarly, significant differences ( $p < 0.05$ ) were observed between the groups with a bachelor's degree or above and those with junior high school education or below, high school education and vocational training education when the contact time ranged from 3 to 5 years. Furthermore, significant differences ( $p < 0.05$ ) were found among all education level groups when the contact time exceeded 5 years (see Figure 7). These results indicate that higher education levels reflect a strong perception of resilient design characteristics. However, no significant difference exists between education level and contact time of less than 1 year ( $p > 0.05$ ).

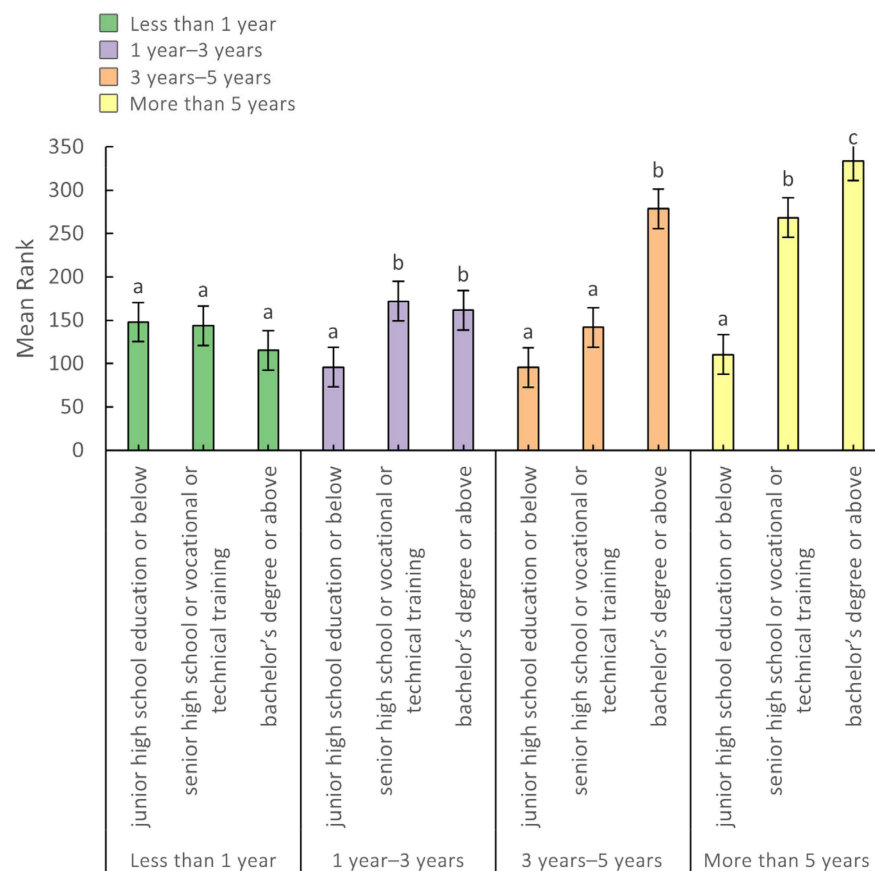


**Figure 7.** Simple effects results of differences between education level within different contact time. The letters (a–c) marking indicate significant differences among groups. Groups sharing the same letter do not differ significantly, while those with different letters show significant differences ( $p < 0.05$ ).

The simple effects analysis revealed no statistically significant interaction between junior high school education and contact time ( $p > 0.05$ ). However, for the groups with high school or vocational training education, significant differences were found in contact time over 5 years, less than 1 year, 1–3 years, and 3–5 years ( $p < 0.05$ ). In the group with a bachelor's degree or above, no significant difference existed between contact time less than 1 and 1–3 years ( $p = 0.42$ ). However, significant differences were observed amongst other contact time groups ( $p < 0.05$ ) (see Figure 8). These results indicate that high levels of education and long contact time correspond to strong perceptions of resilient design characteristics.

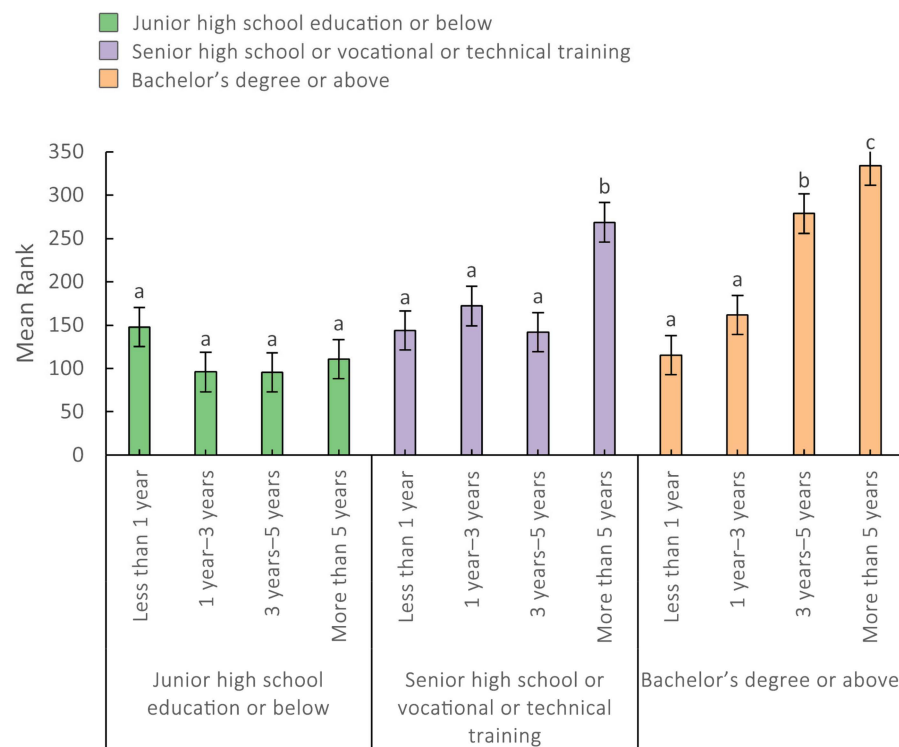


**Figure 8.** Simple effects results of differences between contact time within different education level. The letters (a–c) marking indicate significant differences among groups. Groups sharing the same letter do not differ significantly, while those with different letters show significant differences ( $p < 0.05$ ).

Spearman's rank correlation was computed to assess the relationship between age and perception of resilient design characteristics. The analysis revealed a negative correlation between the two variables ( $r(382) = -0.37, p = 0.00$ ). This study assesses the relationship between the perception of resilient design characteristics and education level, including the length of contact time. The study found a positive correlation between these variables (see Table 4).

**Table 4.** Spearman's correlation results.

|              | Positive  |              | Negative |
|--------------|-----------|--------------|----------|
|              | Education | Contact Time | Age      |
| Robustness   | 0.43 **   | 0.40 **      | −0.33 ** |
| Adaptability | 0.42 **   | 0.37 **      | −0.30 ** |
| Efficiency   | 0.42 **   | 0.39 **      | −0.32 ** |
| Diversity    | 0.47 **   | 0.35 **      | −0.37 ** |
| Connectivity | 0.44 **   | 0.38 **      | −0.34 ** |
| Redundancy   | 0.42 **   | 0.34 **      | −0.33 ** |
| Modularity   | 0.39 **   | 0.41 **      | −0.34 ** |

\*\*  $p < 0.01$ .

## 4. Discussion

### 4.1. Demographic Characteristics and Their Implications for Perception of Resilient Design Characteristics

Among the 384 participants, the proportion of males and females in the sample was relatively balanced. Although the percentage of males was slightly higher, the gender difference was not significant. This allowed for a more comprehensive reflection of the perspectives and experiences of both gender groups regarding resilient design. In terms of age distribution, the proportion of younger participants was slightly higher, indicating a

certain degree of youthfulness in the sample. This provided a solid basis for analyzing how younger individuals perceived resilient design. At the same time, the sample included a considerable proportion of middle-aged and older participants, ensuring that the study covered a broad range of age groups, allowing for the exploration of age-related differences in perception.

Regarding educational background, the distribution was relatively balanced, encompassing participants with low, medium, and high levels of education. This diversity helped to reflect the perceptions of resilient design across different educational levels, enhancing the generalizability and representativeness of the study results. In terms of visit frequency to Yongqing Fang, the majority of participants visited the area frequently, with over 80% visiting regularly. This high frequency of visits provided a strong basis for studying how the public perceived the resilient design characteristics of Yongqing Fang.

#### *4.2. Impact of Physical Elements in Urban Form on Public Perception of Resilient Design Characteristics*

The study investigated the impact of physical elements in urban form on public perception of resilient design characteristics. The results showed that road signs are perceived as having the lowest contribution to robustness (mean = 3.55). In addition, in terms of modularity perception, the results indicated that the public considers the distribution location of social service facilities to have the least contribution to modularity (mean = 3.56). This case may be attributed to their limited usage by the public or their less prominent size and location, resulting in a low perceived significance. This study highlights the significance of the scale and location of physical elements and emphasizes that they should be closely integrated with people's daily activities, thereby influencing the public's perception of resilient design characteristics [32,42].

The results indicated that even with a sufficient number of roads in the space, the public still perceives them to have a low level of redundancy (mean = 3.50). The study shows that this case may be due to exceeding a certain threshold of road quantity and density, leading to public fatigue and decreased attention, consistent with the "arousal theory" [43]. In another finding regarding the perception of road connectivity, the public perceived roads to the central and out of the area to have a lesser contribution to connectivity (mean = 3.54). The study demonstrates that this result may be attributed to the diminished attention caused by the complexity mentioned in the 'arousal theory' and the possibility that the roads themselves are impassable. For example, they may be situated in inconspicuous corners, obstructed by barriers and no pedestrians.

The study found that the public perceived that accessible green spaces have a low contribution to efficiency (mean = 3.56) and that diversified activity areas were considered to have a low contribution to diversity (mean = 3.53). The study indicates that these are all everyday needs and expectations of the public, and their insufficient quantity diminishes the public's perception of resilient design characteristics. Furthermore, the results of this study highlight the idea that the public is highly concerned about infrastructure and spatial structures that are relevant to their lives or of interest to them [42].

Furthermore, notably, disability facilities are perceived to have a low contribution to adaptability (mean = 3.55). The study indicates that the reason is not because these facilities are not essential but rather because they cater to specific groups. Non-disabled individuals may not pay attention to or be concerned about the condition of disability facilities. However, for disabled people, their importance is much higher than others as they are closely related to their daily lives. Therefore, the study shows that evaluations of these designs should gather information from the perspective of specific groups to obtain additional accurate conclusions.

#### *4.3. Influence of Environmental Stimuli on Perceived Resilient Design Characteristics*

The study found that changes in visual factors within environmental stimuli positively influence the public's perception of resilient design characteristics in magnitude and pace. Visual factors can elicit a highly positive public perception and understanding through qualitative changes. This case is evidenced by the results of the qualitative change scenario. This is demonstrated by the results from scenarios involving such transformations, where significant changes in both the visual and experiential aspects of the misting cooling devices elicited public perception. The study emphasizes that people can easily distinguish qualitatively or categorically different stimuli [44]. However, quantitative changes are also noticeable and perceived. As the results indicate, public spaces with different types of lighting exhibit strong resilient design characteristics. Changes in the quantity and intensity of lighting attract public attention, demonstrating the impact of variations in the number of physical elements on public perception. Despite differing from the perspective that an excessive quantity may lead to negative perceptions of redundancy, the study indicates that this case could be because the number of lights has not yet reached its maximum threshold, allowing them to have a positive impact still. However, whether further increases in quantity would continue to yield positive effects, or at what point an increase in quantity would diminish this positivity, remains uncertain.

The study found that fast and slow changes in visual factors positively influence the perception of resilient design characteristics, contrary to the idea that slow changes are often imperceptible [30]. This result indicates that the influence of change effects on perception depends on real-time dynamics, whether involving slowly moving boats or rapidly moving vehicles.

However, routine maintenance, the sudden appearance of a boat entering the calm center of a river, the periodic replacement of large art installations in public spaces, and intermittent changes in small art installations and bill-boards—representing scenarios of regular change, sudden change, large change, and small change, respectively—have not demonstrated that these environmental stimuli can have a more positive impact on public perception. This suggests that the frequency and scale of changes do not necessarily have a positive impact on public perception of resilient design characteristics.

Furthermore, the extent to which the duration of changes positively influences public perception depends on specific circumstances. Based on the results from short-term change scenarios, the public's perception of resilient design characteristics is positive when faced with short-term visual changes. This study emphasizes short-term changes, such as temporary sales or exhibition areas of limited duration, which enhance the freshness of the space and subsequently influence the evaluation of landscape quality [30]. In contrast, the findings indicate that long-term changes, such as prolonged road repairs, did not have a positive impact on public perception.

#### *4.4. Influence of Individual Attributes on Perceiving Resilient Design Characteristics*

The results of individual attributes reveal the impact of age, education level, and contact time differences on the perception of resilient design characteristics. The study found that young people perceive resilient design characteristics more than others, confirming that they are more receptive and sensitive to novelty [25]. In addition, groups with high levels of education demonstrate a great perception of resilient design characteristics, consistent with previous research [26]. Notably, this study emphasizes that individuals have at least 3 years of contact time in the area. Perception of resilient design characteristics relies not only on knowledge but also on familiarity with the space, and 3 years represents a critical threshold for such familiarity. Furthermore, the study confirmed a positive correlation between younger groups' contact time of space and their perception of resilient design

characteristics, but the opposite was observed for older groups. As contact time increases, individuals experience further changes, thereby affecting perception [28]. Moreover, based on the results of the pairwise comparisons, the study found that the middle-aged and elderly people (over 40 years old) and contact time of space more than 3 years, including young and middle-aged people (under 40 years old) with contact time of space less than 3 years, along with those with an education level below a bachelor's degree and contact time of space less than 3 years, exhibited a poor perception of resilient design characteristics.

## 5. Conclusions

The findings of this study reveal that the public's understanding of resilient design characteristics is at a moderate level, indicating potential for enhancing public awareness and comprehension. The study identifies that physical elements, environmental stimuli, and individual attributes significantly influence public perception of resilient design characteristics. Improving resilient design from the perspectives of physical elements and environmental stimuli may be advantageous.

The study suggests the following strategies for resilient design: (1) For low-demand infrastructure, the focus is on improving quality rather than increasing quantity, such as placing and highlighting signs at major intersections. This quality enhancement essentially represents a form of qualitative change, as it alters the nature, functionality, and experience of the infrastructure, thereby influencing public perception of resilience design, rather than relying solely on quantitative changes. (2) Actively promoting social service facilities involves not only increasing the quantity of facilities but, more importantly, enhancing the content, quality, and user experience of the services. This approach allows the public to better understand and perceive the benefits brought by these facilities, thereby achieving the advantages of both quantitative and qualitative improvements. (3) For over-designed facilities and structures, reducing their quantity and simplifying their form can meet functional requirements while avoiding resource waste and visual overload, thereby achieving a balance. This quantitative change is not only reflected in the reduction of the number of elements but also in the simplification of their complexity, ultimately creating a more harmonious and functionally efficient environment. (4) When planning spatial elements, their quantity should be carefully considered to ensure that design requirements are met without exceeding the threshold. (5) By utilizing temporary solutions, space functionality can be rapidly adjusted through flexible, short-term spatial modifications or facility arrangements to accommodate varying usage demands or environmental changes. This approach enables the effective creation of multifunctional spaces in the short term, maximizing the use of limited resources. (6) Designing pedestrian-friendly pathways aims to guide users to move at a slower pace, thereby creating a smooth and comfortable walking experience that induces a sense of gradual flow. On the other hand, frequent and rapid movement of users along the pathway generates a perception of fast change, enhancing the vitality and dynamism of space, thus attracting more users. Additionally, initial use by minority groups can draw additional users [45].

Moreover, this study, based on the influence of individual attributes on the perception of resilient design, suggests that design and planning efforts should place greater emphasis on the viewpoints of younger individuals, those with higher education levels, and groups with over three years of contact with the area, as they demonstrate a stronger perception of resilient design characteristics. Planners and designers can utilize feedback from these groups to optimize resilient design proposals. Additionally, it is essential to enhance educational and outreach efforts specifically targeting the elderly population to improve their awareness and understanding of resilient design characteristics. This enhancement

will subsequently increase their perception abilities and willingness to participate, thereby significantly improving the effectiveness and sustainability of urban resilient design.

While the study provides valuable insights into improving resilient design in public spaces, it has limitations. One significant limitation is that participants were exclusively healthy individuals aged 18 to 65, with no representation from vulnerable groups with mental or physical health challenges. Targeted research on the perceptions of these vulnerable populations in spatial contexts is essential, and future studies should prioritize this area. Furthermore, the impact of increasing infrastructure quantity on system saturation and potential negative effects remains unclear and warrants further investigation. Additionally, future design, planning, and management efforts should focus on groups with limited perceptions of resilient design characteristics, such as the middle-aged and elderly people (over 40 years old) and contact time of space more than 3 years, including young and middle-aged people (under 40 years old) with contact time of space less than 3 years, along with those with an education level below a bachelor's degree and contact time of space less than 3 years. A deeper understanding of these various subgroups is necessary.

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**Data Availability Statement:** The data presented in this study are available on request from the corresponding author due to privacy for the restriction.

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