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Sustainable Development Methods of Urban Slow-traffic System Based on Human Factors Engineering

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Abstract: At present, China's urban transportation is in a period of development and transformation, and there are heated discussions about transportation sustainability. With China's new urban planning strategy and the future development trend of roads, the construction and development of the slow-traffic system have become a new direction of exploration. Through the analysis of human psychology and physiology, this article further explores the sustainable development of slow-traffic systems without sacrificing human welfare. Through the impact on the psychological safety of users based on distance in the street space, and through the three physiological stimulations of color and light on vision, noise on hearing, and ground materials on touch, it strengthens the sense of security for users in road space. Controllability and increased frequency of use. Integrate slow traffic into existing urban arterial roads and public transportation in more possible ways, reactivating street vitality and enriching street life. While achieving the "double carbon" goal, urban roads should be constructed meticulously to improve the quality of life of residents. Nowadays, there are many studies on the use of new technologies for road management, but few on road planning methods that focus on people themselves. After research and discussion, this article can fill the gaps in related research and contribute to the sustainable development of the slow-traffic system.

Keywords: slow-traffic system, human factors engineering, psychological safety, physiological stimulations

1. Introduction

With the increasing development of the economy, people's attention has gradually shifted from focusing on production amount and speed to focusing on production environment and quality. Therefore, the complex interdisciplinary discipline of human factors engineering was born, which aims to study the interaction between humans, machines, and the environment and how to combine them reasonably while ensuring both mental and physical health and comfort. The slow-traffic system is a composite street space that needs to consider multiple travel modes and different applicable groups. It is also a new sustainable development method in modern transportation. How to integrate the slow-traffic system into China's transportation system without encroaching on main roads is a direction that many experts are currently studying. Updating the transportation system and activating street vitality is an opportunity to add human factors engineering to urban transportation development. Psychological safety determines whether people are willing to stay in a space and engage in activities.

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After the human body experiences visual, auditory, and tactile stimulation, it will instinctively judge how to use space under the influence of perception. The combination of the two can guide the crowd to generate more activities and self-control in the slow street space. The construction of slow-traffic systems should not take low-carbon environmental protection as the primary goal, but should naturally change the travel habits of urban residents while ensuring human well-being, thereby achieving the goal of sustainable development.

2. The importance of human factors engineering to slow-traffic system

Slow transportation refers to any form of human or non-motorized transportation used as a way to get around the city, such as walking or cycling.Slow traffic planning and design can reduce road infrastructure construction, improve safety, reduce traditional vehicle-oriented road construction and maintenance costs, and provide a variety of lifestyles for the development of busy cities.

At the same time, slow transportation is also one of the new strategies that China is paying more attention to at this stage, which requires promoting the active transportation friendliness of Chinese cities, contributing to climate and carbon emission goals, and improving the quality of life in cities.

At this stage, most road construction in China is still based on the premise of building road networks to meet surrounding traffic needs. Most cities have yet to integrate transportation planning into their urban master plans. This will cause the distance between people's living and working areas to become longer due to urban expansion [1]. The construction of roads is mostly based on the development and changes of motor transportation as the main construction reference, resulting in problems of blind planning and over-construction. Irrational planning between different areas of the city makes the traffic situation chaotic. Motorized lanes begin to occupy non-motorized lanes for parking, forcing non-motorized vehicles and even pedestrians to enter the motorized lanes, thus falling into a vicious cycle. Good and clear slow traffic planning can effectively isolate different vehicle types, enrich the way people use the road, and optimize the user experience.

By integrating human factors engineering, psychological and physiological dimensions can be used to influence the way and rhythm of road space used by different groups of people, and gradually reverse the road development model while creating a safe, comfortable, and healthy environment. Through psychological hints and external physiological discipline pedestrians and drivers, their behavior on the road use is standardized, so that the road system has a healthy and comfortable environment while reducing the probability of accidents.

3. The particularities and challenges of China’s transportation system

A dense population and abundant land use make people's living circle relatively fixed. People's daily lives are basically fixed around their residences, and the fact that they do not need to travel long distances is a natural advantage of the development of China's active transportation system. Residents can complete most of their needs for work, leisure, shopping, and entertainment in the surrounding area. Most first-tier and second-tier cities already meet the concept of a "15-minute living circle", and the basic supporting facilities related to life are relatively complete and abundant. As the urbanization process intensifies, the uneven development of the city has gradually made the age divisions more obvious. The new urban areas are mostly young people, while the old cities are mostly urban aborigines and children. The age gap between the two makes their travel methods and needs significantly different. Young white-collar workers need to quickly pass through and reach their workplaces to shorten their commute time, while the elderly and children need to pay more attention to accessibility and safety around their homes. The reasonable urbanization of regional populations requires the balanced development of regional transportation structures, while urbanization varies within different regions [2]. The obvious differences in the residential population have led to the

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formation of many living circles for different ages within the city, exacerbating the development trend of mismatched large-scale functional construction. For example, medical facilities and educational facilities are more likely to be built in old cities to facilitate medical treatment for the elderly and schooling for children, while large enterprises prefer new urban areas with better facilities around the city.

Because Chinese cities cover a large area and have a long development timeline, there are many streets, alleys, and other relatively narrow back streets. These are often the areas that urban residents pass through and use the most every day, and these are places where culture and memories from various periods are intricately deposited. Whether it is used as a basic urban street or connected with the characteristics of surrounding areas to become a cultural display street, the functions of back streets and alleys can be more diversified and utilized more fully. At the same time, the scale of these roads is very suitable for the development of slow traffic and the formation of a road system. Whether walking or cycling, they are good choices. This requires slow-moving roads to be well integrated with the main roads in a point-to-line manner. If the city's main roads and public transportation are the aorta, slow traffic is needed as capillaries to dredge and transport the last part. Slow traffic should not only be built on the surface of the city attached to the main roads but should also go deep into the most complex internal small roads in the city, planning and building from the source of residents' daily needs.

After experiencing streets being reduced to large-scale spaces designed for cars, Chinese cities began to realize that urban construction and development are ultimately suitable for human habitation, and began to turn to the construction of people-oriented cities. Since 2012, they have gradually promoted the planning and implementation of urban slow-traffic systems. put up. Too many goals prevent the slow-traffic system from having clear construction ideas and service objects. Slow traffic that cannot be well integrated into the city's main roads will bring many stubborn traffic problems to urban traffic.

3.1. Facility occupying the road

The forced addition of slow-traffic systems under unreasonable planning has resulted in a squeeze on motor vehicle lanes and original parking spaces. More and more motor vehicles are beginning to occupy the service roads for parking and passing quickly. As a result, bicycles and electric vehicles cannot travel normally and are forced to use motor vehicle lanes, creating a vicious cycle. On the basis that the sidewalks do not meet the specified width of the planning standards, they also suffer from municipal and infrastructure occupations, such as transformer boxes, pedestrian bridge steps, and trash cans. The originally smooth walking route is interrupted, and pedestrians do not feel safe and comfortable enough in such a chronic street space, thus reducing their desire to travel on foot or by bicycle, which is not conducive to the construction of a slow-traffic system.

3.2. The sidewalks are in disrepair and ineffective renovations

Due to the large population and limited access roads, main roads and surrounding slow-traffic roads bear heavy commuting pressure and cannot be repaired quickly when damage is discovered. After a long period of use, the pavement begins to fall off, causing the exposed soil of the street trees to begin to erode around, affecting pedestrians' experiences, reducing their desire to stay on the street, and thus reducing the vitality of street life. It is not conducive to the later use of the slow-traffic system to provide a safe and rich street life for pedestrians. In recent years, the government has begun to pay attention to the construction of refined streets. Roads in the city center have begun to be repaired and renovated, and new sidewalk paving has been built to show the city's cultural heritage. Most of the dark-patterned bumps and convexes in the pavement are in awkward positions and occupy a small

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and irregular area, which is not conducive to the passage and use of disabled people, old and young people. To a certain extent, the elderly and children are the main participants in street life, and disabled people, as a vulnerable group, should be paid attention to. The uncertain walking environment is still not conducive to the integration and development of the slow-traffic system.

3.3. Relevant infrastructure is imperfect

Improving people's happiness when using the streets requires corresponding infrastructure to assist. Clear road sign guidance and exclusive parking areas for cyclists need to be separated from pure pedestrians. This can not only ensure the riding speed but also reduce the probability of accidents and ensure that both groups have independent and complete space for use. At this stage, most cities in China have begun to try to use shared cycling to share the pressure of motorized transportation, and encourage people to use slow transportation + public transportation to travel. Traffic congestion is a major problem for sustainable urban development; heavy traffic inevitably reduces the happiness of life and increases the cost of living, leading to a loss of the labor force in urban areas [3]. Since the public transportation network does not cover all people's living areas, the use of electric vehicles is increasing day by day. Coupled with the unreasonable planning of shared bicycles and the large influx of related companies into the market, the planning of parking locations for bicycles cannot meet the corresponding number, and people begin to occupy large areas of sidewalk space for parking. Due to the compact and flexible nature of cycling vehicles, parking problems on back streets are even more severe. At the same time, relevant road signs, road signs, and road dividing lines need to be more complete and clear. The first step for slow traffic to help main roads share traffic pressure is to radiate the signs and related facilities required for motor vehicles to cycling vehicles to ensure that walking, cycling and vehicles can have independent operation and use space.

4. Sustainable development model based on human factors engineering

Road safety has become a major public health problem and has gained attention from both the government and the public [4]. Slow traffic is currently regarded as the most suitable main strategy for sustainable transportation development. While affecting modern transportation methods, it can effectively provide the urban environment and make urban construction more refined. These premises are often designed with the main purpose of focusing on climate change and reducing carbon emissions, often ignoring the well-being of the first users of the city. As builders, participants, and revolutionaries of urban transportation, people first need to ensure their happiness and quality of life. A sustainable system that comes at the expense of human well-being is not truly sustainable, and its longevity and efficiency will be greatly reduced. As the name suggests, slow traffic is slower than motorized traffic. This results in greater reaction times, visual capture, and sensitivity to the surrounding environment. Therefore, people need to feel safe and comfortable in the slow-travel system. Roadway studies mostly focused on drivers, which is expected as industrial societies have been car cultures for decades and many of the world's most populous countries are increasingly adopting motorized vehicles, leading to a rise in traffic-related trauma [5]. At the same time, except for drivers, unsafe driving poses risks to vulnerable road users(i.e., pedestrians, cyclists), further emphasizing driving safety [6]. Coupled with the particularity of China's transportation system, the integration of slow-traffic roads and main roads requires the stimulation of human physiological responses to achieve a certain management effect, subtly affecting the judgment of drivers and pedestrians on-road use.

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4.1. Psychological safety in slow travel spaces

The psychology area shows how people convey social meaning through interpersonal distances and, ultimately, how social and physical dimensions of space interplay with one another [7]. Meanwhile, Maslow proposed in the hierarchy of needs theory model that safety needs are the second most basic need for people after physiological needs, followed by belongingness, respect, and morality. Therefore, slow traffic needs to satisfy people's need for spiritual security in public spaces to the greatest extent. He believes that psychological security is "a feeling of confidence, security, freedom, and comfort that is free from insecurity and anxiety, especially the feeling of meeting a person's current needs." Therefore, when the access road is squeezed and occupied by other groups, people will judge that the space they are in is unsafe and want to quickly leave or stay away from the space.

4.1.1. Distance

A sense of security can be understood as territorial awareness to a certain extent. People are generally in a state of relative vigilance in unfamiliar environments. Boundary identification also differs for different groups of people and spaces. Tsinghua professor Zhang Li once proposed the identification of five spatial scales in urban ergonomics: group scale, distant body scale, mid-body scale, near-body scale, and body surface scale [8]. Among them, the group scale and the remote body scale are the two most important scales in slow traffic. Due to the different reachable range of people's sight, people's response speed to the surrounding environment will also be different. At larger spatial scales, people experience sensory alienation from each other. If too fast speed is added at this time, people's ability to react and observe the surrounding situation will be significantly weakened, and it will be difficult to establish a sense of security in the space they are in a short period, so they want to escape or pass through the space quickly.

Unlike open square spaces, street systems dominated by linear spaces are often not enough to support people's social distance, which is consistent with psychological safety in long and narrow spaces. Different distances indicate different relationships between people. From public distance to intimate distance, it indicates people's default range of security. Studies have shown that people will only feel comfortable when the public distance is greater than 3.6 meters, which is also the most common relationship in slow-traffic systems. Below 3.6 meters to 1.2 meters is the social distance, which is the range where people's communication reactions and sensory reactions become increasingly sensitive. People's territorial awareness and sense of being invaded generally arise from different types of behaviors and activities. This shows that although cyclists and pedestrians are both users of the slow-traffic system, they also need to guarantee a certain physical isolation or reserve sufficient distance. For example, at Avenues Mermoz Et in Lyon, France, there is also a soft separation of about 1.5 meters between the cycling paths and walking paths in the slow-moving system (Figure 1). It is worth noting that both too large a space and too small a space can have an impact on people's psychology, making them feel uneasy and anxious. For example, at night people tend to return to indoor environments in confined spaces rather than resting in empty open spaces. This feeling shows to a certain extent that in an open space full of uncertainty like Chronic Space, moderately compressing the distance between people will increase people's use and stay time on Chronic Road.

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Figure 1: Avenues Mermoz Et in Lyon, France [9]

4.1.2. Green environment exposure rate

Green environment exposure rate generally includes green space rate, green vision rate, and green vision, which is an important indicator of walkability in urban slow traffic. The greening rate refers to the proportion of green plants within a person's field of vision. Studies have shown that a greening rate of more than 15% is conducive to people's physical and mental pleasure, and can effectively improve happiness and reduce anxiety. At the same time, the planting density and matching height of vegetation in green areas will also have different effects on the human body. A height higher than the average human perspective and a dense planting density are conducive to making the space a relatively private space, which can encourage people to stay in public spaces. Create a sense of security. Although vegetation cover helps improve drivers' attention and pedestrians' sense of security, high density, and height are not conducive to vehicles' reasonable judgment of the traffic situation on the adjacent road, and the interface between slow-moving traffic and main roads should be avoided. While ensuring the reduction of accidents, slow-traffic system should improve people's sense of belonging and improving concentration to the space they are in to ensure the purity of space use. A high greening rate and low height are patterns that are more compatible with slow traffic. While serving as a soft separation between lanes, it can also ensure the unobstructed line of sight of the crowd, and at the same time increase the possibility of pedestrians judging the road space, repeatedly emphasizing and confirming the safety of the space they are in.

4.2. Physiological self-monitoring in slow travel spaces

Yang Gale mentioned in his book that "outdoor space life is a potentially self-reinforcing process" [10]. The biggest challenge China faces in the development of slow-traffic systems is the difficulty of managing its excessive population. However, influencing and guiding people through physiological instinctive stimulation undoubtedly plays an auxiliary role in coercive management. People's instinctive behaviors in the face of physiological stimulation mainly come from vision, hearing, and touch. Instinct selection and avoidance of discomfort and more special perceptions are the first reactions of humans in unfamiliar public spaces. The visual stimulation of color and light sources can affect both drivers and pedestrians at the same time. By adjusting the saturation of colors and the relationship between cold and warm, the brain is stimulated to react and judge. At the same time, the light source is an important indicator element at night. The density of its arrangement and

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the intensity of individual light can directly affect the crowd's perception of everything at the moment. Judgment of environment.

In addition, there is also a sense of touch that can affect both drivers and pedestrians. At the junction of the slow-traffic system and the main road, you can often find paving methods with different concave and convex levels and the existence of speed bumps. These are the things that designers hope to remind people of the changes in space through a different tactile and driving feel from the current roads. The initial use of touch to inform and influence people's movement came from the design of blind paths in the streets. But it also reminds us that different paving can affect the speed and mode of passing through the street, thereby helping chronic street systems border the city's main thoroughfares. The last thing that only affects the walking crowd is hearing. Traffic noise at different decibel levels will directly affect the nature of activities in the adjacent streets. For example, the choice of light sources in residential areas is generally relatively soft, and the road materials tend to be sound-absorbing materials and slow-moving street paving to reduce the impact of motorized traffic on residences.

Whether visual, auditory, or tactile, they all have an impact on the sustainability of the city. The three elements have different requirements for road materials and infrastructure construction standards in different road environments, which is conducive to allowing drivers and pedestrians to self-monitor the road space.

4.2.1. Physiological perception of color

The "Color Experience Pyramid" theory proposed by Frank Mahnke of the International Association of Color Consultants (IAAC) shows that people will have instinctive biological reactions to the stimulation of certain colors, and these reactions cannot be controlled by people through later learning. In the field of psychology, color is a powerful emotional and perceptual trigger. Designers can use different colors to trigger a range of feelings and emotional reactions in users. Generally, by adjusting the saturation, brightness, and darkness of the color, users can have different perceptions of the size, depth, and shape of objects. Take, for example, BIG and WXY's planned transformation of streets and public spaces in downtown Brooklyn.The city government hopes to reposition the streets and gradually change the streets in the city center to use "slow traffic + public transportation" as the main mode of transportation. Breathe new vitality into public spaces. The design company uses a large amount of green and blue to make people feel energetic and calm on the road and uses brighter yellow to mark public leisure areas and public transportation waiting areas to regulate traffic behavior in the streets so that the high-purity yellow can be used in the streets (Figure 2). Quickly attract people's attention in a short time. However excessive use can cause people to feel tired.

Color, like everything else, has two sides. Blindly filling a space with high-brightness and high-saturation colors often makes people feel uncomfortable. Therefore, colors with high brightness and purity such as yellow and red often appear on road signs to remind drivers and pedestrians by stimulating their senses. Dotted or linear red can be used as a guideline on the ground, but it is difficult to divide the road. Slow-moving streets are not only for people to pass quickly, but also to reactivate street life, increase people's participation, and improve the happiness of surrounding residents. Facing different urban areas, the color application of the slow-traffic system must also be adapted to local conditions. For example, the vestibule space of kindergartens and schools is suitable for marking with multiple colors, but the area bordering the main road only needs to be marked with a single color to enhance the guidance function and speed up the passage of people.

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Figure 2: The imagined future for Downtown Brooklyn. [11]

4.2.2. Physiological perception of light

Artificial lighting, other than daytime lighting, is currently the most controversial urban element among psychologists. In addition to providing necessary night lighting, excessive lamp effects and lighting will disrupt the biological clock of urban residents, thereby affecting people's health. However, if the light is well used and adjusted according to its saturation and intensity to only activate the cognitive skills of the perceiver, it can play a beneficial role in the nighttime operation of the slow-traffic system. Street lights and ground lights provide different levels of lighting effects for the surrounding environment, which helps improve drivers' and pedestrians' sense of direction. Subtle intensity differences are used to divide the road use levels. Help pedestrians and drivers distinguish between main roads and slow-moving streets through different light distances, brightness, and colors. At the same time, on pedestrian paths with many landscapes, landscape lights and road lights help pedestrians avoid the edges of the road, discover potential safety hazards, and stay away from cycling roads.

Slow-traffic systems are different from urban main roads except for the passage of people and goods. There is also a need to increase the possibilities for street life and increase the frequency and duration of use of the streets by people. For different areas, ambient lighting should be provided that is different from that of the main road. For example, warm lighting in residential areas can clearly distinguish the atmosphere from the main road, creating a warm and slow-paced feeling. Use small-diameter lighting to emphasize the areas where pedestrians are walking and blur the surrounding environment.

4.2.3. Noise avoidance

The human subjective reaction to it is expressed by annoyance. These findings are important at both the society and the individual level, in as much as they may help in regulating in a more efficient way the planning of road traffic activity in order to secure at least the minimum of comfort for the affected population [12]. Urban arterial roads inevitably produce traffic noise, which will prompt a rapid decline in pedestrians' ratings of road space. Slow-traffic systems built on urban main roads have a poor ability to attract pedestrians and are generally only used as the main way to share the pressure of urban main roads and motorized traffic. If you want to quickly establish and enhance the status of slow traffic in the hearts of urban residents, you need to selectively build different slow traffic corridors in the slow-traffic system. Select some areas away from the city's main roads, pass by, or use back-street roads and landscape areas, to reduce noise pollution as much as possible. It makes the perception of sound pleasant and relaxing for cyclists and pedestrians and makes a judgment that the slow-moving space is relatively safe, increasing the frequency of people using slow-moving traffic.

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4.2.4. Physiological response to touch

The first application of touch on the road was to help blind people set up different bumps at the starting point, turns, and service facilities on the sidewalk to remind them of changes in road conditions and dangerous situations ahead. Different pavements will cause different tactile sensations on the soles of pedestrians' feet. Soft plastic floors have completely different reactions to hard asphalt or bricks. When people touch plastic materials, they instinctively think of this area as a place for people to stay and move based on the symbolism in their consciousness. In the same way, different tiles will cause people to make different judgments about the site and guide people to have different activities in the space.

Vibration tactile sensation is the most easily ignored tactile feedback among all tactile sensations. Different paving densities can increase the vibration frequency and amplitude of passing motor vehicles and riding vehicles. The impact of vibration on people mainly depends on the intensity of the vibration, followed by the frequency and duration of the vibration. To ensure road safety, passing vehicles should ensure minimum vibration amplitude. At the same time, when the vibration frequency and duration are long, the human body will change from "feeling threshold" where the vibration information is just felt to "discomfort threshold", from being tolerable to feeling uncomfortable, thereby reducing the traffic speed to ensure that the tires and pavement are slowed down. The friction frequency of the device is reduced, thereby reducing the vibration frequency. For example, when motor vehicles and cyclists pass by masonry pavements that are common in European cities (Figure 3), they will feel the numbness and discomfort caused by the vibration, thus slowing down. This greatly reduces the speed of vehicles and ensures the safety of pedestrians.

Figure 3: The Porphyry pavement in Italy.

5. Conclusion

The development of the slow-traffic system is not only to achieve China's "double carbon" goal but also to assist in the comprehensive upgrade of the original main road system and public transportation system. A transfer station that converts slow traffic into motorized traffic can be regarded as both a starting point and an endpoint, effectively connecting various destinations. Slow traffic not only plays the role of transportation but also needs to reactivate the vitality of urban streets and increase the participation and duration of urban residents in street life. As the most important users of traffic roads, urban residents' feelings about road space are very important. Through human factors engineering, the psychological safety of urban residents on the road is a primary consideration. Road scale and green exposure can change people's level of psychological safety, thus forcing people to respond to the way the road space is used. It is helpful to control the traffic speed of road nodes.

Based on psychological impact, to promote people's behavioral awareness of self-control in road space. Physiological stimulation of the human body through vision, hearing, and touch is required to guide the body to respond. Colors and lights with different brightness and saturation can accurately

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convey the function and atmosphere of road nodes to drivers and pedestrians, thereby affecting the activities generated on the road. Effectively avoid the mixing of vehicles of different classes. A slow-traffic system that simply relies on main roads cannot attract people to stay or use the slow-traffic system frequently. The slow-traffic system can stay away from noisy main roads by properly avoiding and using backstreet roads, reducing the situation where people ignore the slow-traffic system to avoid noise. At the same time, the vibration touch caused by road pavement will repeatedly break through the driver's "feeling threshold" for vibration, thereby reducing the driving speed. The response of pedestrians to the ontological symbolic awareness of pavement materials will effectively increase the possibility of slow-moving streets and increase the time and frequency of use.

It is necessary to apply human factors engineering to slow-traffic systems. Only in this way can people truly achieve a people-centered sustainable development approach and help in the planning and construction of slow-traffic systems without sacrificing human well-being.

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