Interacting with landscapes beyond windshield: Affordances actualisation on scenic road rest areas

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Abstract

Context:
Scenic roads are world-wide implemented as policies that turn automobility into landscape capital. As an essential component of scenic road systems, rest areas provide spaces for people to interact with roadside landscapes, enhancing the quality of experiences of recreational motorists. However, the understanding of scenic road rest area usage still lacks empirical evidence.

Objectives:
Through the lens of the affordance theory, this study developed an empirical approach to explore the affordance actualisation mechanism focused on the context of motorists-rest area interaction.

Methods:
Our team has conducted site observation and behaviour mapping on seven rest areas along the Nujiang Beautiful Road in northwest Yunnan, China. By conceptualising Surface Materials and Distance References as landscapes’ physical determinants, and Fixed Functional Meanings and Perceived Use Patterns as individuals’ perceptual determinants, this research investigates how these determinants quantitatively affect affordance actualisation.

Results:
The results outlined a behavioural profile about the usage of rest areas on scenic roads and further revealed that: (1) inspired affordances and anticipated affordances respectively acted on people's experiences and satisfaction; (2) perceptual determinants are more proactive on actualising affordances compared with physical determinants; (3) traffic conflicts, landscape availability and distance to parking contributed to affordance actualisation vacancy.

Conclusion:
The findings may reveal some theoretical insights about the affordance actualisation mechanism via an empirical approach and can be used to assist evidence-based planning and design of scenic road rest areas.

1 Introduction

Under the strategic background of integrative tourism and transportation development, scenic roads unfold the regional landscape for motorists while generating tourism income for roadside communities. The designations and constructions of scenic roads are worldwide practices that validate the idea and possibility of converting automobility into landscape capital. Although most countries and regions of the world have a long history of exploring their landscape through routes and roads, projects of scenic roads did not become a possibility until the age of the automobile. From the 1930s to the 1960s, the increasing numbers of private automobiles stimulated the demand for recreational driving. As a consequence, the increasing need for motorised access to nature gave rise to road projects of parkways that could connect the wilderness of National Parks, and holiday roads across the countryside and scenic mountains. These early models of scenic roads offered travellers easily consumable automotive landscapes, giving urban residents the chance to enjoy a break from their industrialised surroundings and efficiency-oriented routine (Schimek et al., 2022). The development of this new touristic sector also brought economic benefits to remote and less developed areas (Zeller, 2016).

Taking into account the favourable scenario, many countries and their respective transportation or national tourism departments started to implement scenic road projects at the national level since the 1980s. In 1981, the German Tourism Association announced the creation of ‘Deutsche Ferienstraßen’, a scenic route collection that elected from qualified itinerary routes that offered by various companies and organisations. In 1996, the German National Tourist Board and German Automobile Club also joined in funding, constructing, and operating these designated routes, aiming to maintain the high-quality experiences of the national scenic roads (Deutscher Tourismusverband e.V, 2017). In the U.S, the Intermodal Surface Transportation Efficiency Act of 1991 launched the ‘National Scenic Byway Program’. According to the act, the Federal Highway Administration (2021) initiated the designation of the ‘All-American Road’ and the ‘National Scenic Byway’, establishing the two-tier system of the scenic road network inside the country. In Norway, the government expended 216 million NOK on scenic road projects as a national tourism strategy. After a four-year trial project from 1994 to 1997, the Norwegian Public Roads Administration finally designated 18 routes with a total length of over 2000 km entitled ‘Nasjonale turistveger’, or the Norwegian Scenic Routes in direct translation (Larsen, 2016; Pasgaard et al., 2020). In China, the State Council twice proposed designating 25 scenic roads across the country in the national five-year tourism development plan in 2016 and 2021 (State Council of the P.R.China, 2021). Local governments of different provinces also began to explore the route selection and landscape design of scenic roads on a regional scale.

The worldwide trend of authority designation intends to guide the development of scenic roads at a high-quality and sustainable pace. Since the advent of scenic roads offers motorists the panoramic perception of the world beyond the windshield (Hvattum et al., 2016), the visual quality of roadside landscapes naturally becomes the most predominant condition among all designation requirements. Smith (1992) investigated the visual quality of scenic roads by recruiting operating teams to collect photographs along the case roads from three types of view, panoramas, scenes and focal points, and rate them according to 42 given items of landscape features. This evaluation method was then used by the authorities as references for scenic road designation. In response to the difference in preference between experts and the public, Clay and Smidt (2004) collected photographs of roadside landscapes and invited landscape architects and the general public to rate them according to indicators and scenic beauty, using correlation, regression, and factor analysis to unveil the issues of visual quality evaluation for better road landscape planning. Gandy and Meitner's (2007) created a driving simulator that could offer participants with audio and video content of a scenic road. Their results provided an accurate measurement of roadside landscape quality based on the immersive experience. In
recent years, GIS-based visibility analysis becomes a popular tool for the landscape governance of scenic roads. By using DEM and road vector, Chamberlain and Meitner (2013) calculated the viewshed and visual magnitude of a tourist highway through the Clayoquot Sound UNESCO Biosphere Reserve in Canada, aiming to better understand the framework behind the design and management of scenic roads. Anderson and Rex (2019) adopt distance decay weightings and LiDAR data to capture obstructive vegetation curtains while driving on the Blue Ridge Parkway, and their results were used as evidence for roadside landscape conservation planning.

Despite the visual focus on scenic road designation, planning and management, other ways of human-landscape interactions are generally overlooked. Hvattum et al. (2016) argue that scenic roads are not only a visual orchestration of views and vistas but also a means to participate in the landscape, both epistemologically and perceptually. Automobility gives people more opportunities to establish a direct contact with nature, rather than creating barriers to constrain people to observe nature only through the windshield. However, free mobility does not equal free experience. Compared with the early stage of the automobile era, contemporary traffic rules and road safety awareness restrain motorists from stopping cars and embracing the landscapes at any time. Therefore, rest areas along scenic roads become crucial in the context of recreational driving since they open up spaces free from rules and worries, giving people more opportunities to interact with roadside landscapes.

After the mid-20th century, many interregional and international highway programs were initiated by governments to stimulate the economy in Western countries (Mom, 2005). Long-distance and high-speed road travel directly impact drivers’ need for roadside spots to stop and relax. Therefore, the construction of service and rest areas has been systematically incorporated into the plans of modern highway networks. Today, setting rest areas on motorways is considered an international practice to resolve safety issues with drowsy driving and other emergencies (Jung et al., 2017; Reyner et al., 2010; Terabe et al., 2022). In the context of scenic driving, rest areas also act as recreational sites that can positively impact travellers’ experiences. In early cases, the concept of rest area was associated with roadside parks, initially sited by drivers stopping to fulfil the needs for rest, sightseeing, or eating (Dowling, 2008). When a road is designated as a scenic byway, measures for roadside improvement are usually carried out to convert its rest areas or roadside parks into tourism-oriented facilities such as visitor centres, service areas, trails, and overlook points (Yamada et al., 2002). The recent scenic road design in Norway offered a typical example. The Norwegian Scenic Routes project involves the construction of about 250 rest areas and viewpoints along the 18 selected roads (Gustavsen, 2016). The strategy is to hire architects, landscape architects, and artists to design architectural and artistic installations as place-making practices (Pasgaard et al., 2020). These designs are planned to facilitate the tourist gaze on the Nordic landscape, successfully turning the landscapes into tourist attractions (Larsen, 2014).

Since rest areas have gradually become indispensable in highway and scenic road systems, many theories and guidelines have been outlined as references for their construction. Rest areas are intended to provide drivers with a structure for basic relaxation to ensure road safety. Appropriate location (reasonable spacing between each rest area) and necessary facilities (e.g., water supply and toilet for physiological needs, and green space to recover attention) are regarded as key indicators of user-friendly designs of a rest area (Fowler et al., 1989; Guochao et al., 2014; Pérez-Acebo et al., 2022). However, there is growing evidence showing that road and rest area constructions pose threats to the ecosystem of roadside landscapes (Lin et al., 2019). So, the effective design of these rest areas should consider solutions that maximise the utilisation of site features such as vegetation, rock outcrops, and water and historical features (Reierson & Adams, 1981). Echániz (2009) argues that rest areas should go beyond the primary idea of providing drivers with a place to rest and also be used to deepen the understanding and appreciation of the local environmental values. Apart from location and amenities, the design focus should reflect features that are associated with the interpretation and accessibility of the nearby landscapes. Nonetheless, this shift in perspective brings new challenges for the settings of the rest area when it comes to promoting more activities of human-landscape interaction. Albeit theories and guidelines that have been put forward, how people interact with the landscapes of rest areas is still under-researched. Although Denstadli and Jacobsen (2011) have conducted tourist satisfaction research on rest area facilities and provided pertinent suggestions for scenic road management. But compared with their approach of individuals’ attitude-based satisfaction, user’s behaviour is a more direct way to reveal the on-site experience of motorists. However, due to the lack of empirical evidence, the setting of people's behaviour in rest area remains to be explored.

Seeking to understand how motorist interact with the landscapes of the rest areas on scenic roads, this study adopts Gibson’s (2015) affordance theory as a framework to organize the follow-up empirical analysis. Affordances are what the environment provides to support individuals’ behaviours. The occurrence of a certain behaviour denotes a corresponding affordance to be ‘actualised’ by an individual. The actualisation process is a crucial stage in human-landscape interaction, affected by both the landscapes’ physical attribute and individuals’ affordance perception, and this is why affordances have been defined as ‘relational properties’ between environment and individual (Heft, 1989). In environment behaviour research, the affordance theory provides insight on deciphering the interaction mechanism between a given kind of landscape and its specific users, such as children and playescape (Kreutz et al., 2021; Wishart et al., 2019), residents and residential landscape (Hadavi et al., 2015; Hadavi & Kaplan, 2016; Kyttä et al., 2013), tourists and attractions (Chen & Wu, 2021), cyclists and cycleway (Qi et al., 2021). Although previous studies have already investigated how the landscapes’ physical attributes, functional meanings, spatial features, or individual perceptions can lead to different behavioural outcomes, there is still a research gap when it comes to interpreting these aspects as co-determinants within a case and examining which one is essential to affordance actualisation. Based on the relational ontology of affordance, this study encapsulated material and spatial attributes as the landscapes’ physical dimension, and categorized meanings and use patterns as people’s perceptual dimension to explore a new empirical method to unveil the relationship between these dimensions and determinants. The results presented can hopefully provide insights on motorists-rest areas interaction that can be used for evidence-based planning and design for scenic roads.

2 Data And Methods

2.1 Study area

‘Nuijiang Beautiful Road’ is a scenic road located in the UNESCO world natural heritage site ‘Three Parallel Rivers of Yunnan Protected Areas’, close to the China-Myanmar border. The road starts from Lushui city (25.904833°N, 98.628471°E) and ends at Bingzhongluo town (28.013333°N, 98.911944°E) in Yunnan
Province, China. It stretches out 280 km along the Salween River and passes through the deep-incised landform of the southern Hengduan Mountains, offering splendid gorges, forests, glaciers, and alpine karst landscapes for travellers. Since 2017, the government has invested more than 6.8 billion CNY in upgrading road landscapes and roadside rest areas to bolster the development of self-drive tourism. Now the road has more than 25 rest areas of various sizes, with different facilities and designs that offer recreational driving-related services. Seven representative rest areas of this road were included in this study according to their different sizes, locations, and services offered (Fig. 1).

2.2 Data collection

Behaviour mapping is adequate in collecting affordances data since it records the information of both activities and their locations, implying what settings of the landscape support which kind of human activities (Goličnik Marušić, 2016; Park et al., 2020; Sun et al., 2020). To ensure a sufficient data volume, this research was conducted during a week-long public holiday from May 1st to 7th, 2021. Six pre-trained landscape architects were hired to conduct 8 hours of observation on each site, and each was assigned a non-overlapped area. The observation protocol was based on recording drivers' locations and types of activities every half-hour, from 9:00 to 17:00. According to a preliminary investigation, this is the most effective period to cover the peaks of visitors to rest areas.

A layout plan that records the environmental features is often used as the base map for behaviour mapping. However, motorists’ affordances perception is based on multi-factors rather than a single aspect of the site features. In this case, a common layout plan may have limitations in recording the site information, failing to unveil the determinants of affordance actualisation. In this regard, this study adopts the ‘layer-cake’ method in landscape analysis to develop a multi-layer layout plan for behaviour mapping and analysis (Qi et al., 2022). We used UAV aerial survey to generate the orthoimages of the selected rest areas. Then, combining the orthoimages and our on-site investigation, we produced 4 map layers, which respectively recorded the conceptualised determinants of affordances actualisation.

- Surface Materials: records the objects or the material settings of the site, such as asphalt, concrete, grassland, trees, buildings, and other materials that make up the rest area. This layer is affiliated with landscapes’ physical dimension, indicating the material compositions affect affordances actualisation.
- Distance References: records the spatial distance from event venues to significant sites of the rest area, such as entrances, viewpoints, and parking lots. This layer also belongs to the physical dimension, and it was created to testify whether affordance actualisation is affected by the distance of the venues.
- Fixed Functional Meanings: records the functional meanings of objects or designs that are based on common sense or everyday life, e.g., roads, squares, parking areas, greenings, nature and other spaces that constitute the rest area. This layer is particularly related to people’s perceptual dimension and reflects how their previous experiences affect the affordance actualisation process.
- Perceived Use Patterns: records other people's ongoing use patterns of the corresponding sites that are perceived by individuals at a time, for example, seeing others taking pictures at a spot makes people realise good places for photography. This layer also derives from the perceptual dimension, and it was created after the observation period and used to investigate if the perceived utilised affordance encourages more actualisation of the same affordance.

2.3 Data processing

We adopted QGIS (version 3.10) and Python (Shapely and GeoPandas, open-source Python packages) for data processing and analysis. Given that a hexagonal grid has been acknowledged to be more relevant than a rectangular grid for analysing people’s movement paths (Clauzel et al., 2018), the rest areas were generalised into a lattice of hexagonal grids. To appropriately consider the spatial scale of environmental behaviours and the statistic requirements of sample-variable relation in the following analysis, the side length of each hexagon was set as 3 m, covering an activity space of 23.38 m². Besides measuring the number of different behaviours in the grid units, the hexagon lattice was also projected on the map to calculate the corresponding descriptors for the four determinant matrices described below.

- Surface Materials: included Asphalt, Coloured asphalt, Concrete, Stonework, Steel, Gravel, Plastic wood, Grasscrete, Bare soil, Water, Tree, Shrubs, Grass, Building, and Installation. All of these 15 descriptors of materials and landcover types that have been found on the sites included in this study. Each descriptor is valued by the area of the corresponding material in every grid.
- Distance References: included 5 descriptors, valued by the nearest distance from the centroid of each grid cell to the place with significance to motorists: the Parking area, Entrance, Scenic road, Centroid and Border (the side offers natural scenery) of the rest area.
- Fixed Functional Meanings: included Carriageway, Walkway, Cycleway, Car park, Open space, Greening, Platform, Amenity, Outdoor furniture, Farmland, Natural environment, Vacant lands. The values of these 12 descriptors indicate the areas of places with particular meanings in the grids.
- Perceived Use Patterns: included 15 descriptors which recorded the number of ongoing activities of the same type that was observed by one individual at a time in each grid. These patterns could be calculated with the following equations:

\[ PUP_i = \sum PUP_{ij} \]

\[ PUP_{ij} = \begin{cases} 0, & n_{ij} \leq 1 \\ n_{ij} - 1, & n_{ij} > 1 \end{cases} \]
where $P_{ij}$ is the matrix of the Perceived Use Patterns, $i$ is the type of observed activity, $j$ is the time of observation, and $n_{ij}$ indicates the number of a particular type of activity that has been observed at a time. The value of $P_{ij}$ recorded the number of people who are carrying out the same activity that has been perceived by the last joiner other than oneself. If only one person or no one is engaged in an activity at a given time ($n_{ij} \leq 1$), then there is no use pattern being perceived by others.

### 2.4 Statistical analysis

A series of statistical analyses for matrix variables was adopted to quantify the mechanism of affordance actualisation. Firstly, to testify if the aforementioned determinants were valid, a Mantel Test was employed to outline the correlations between actualised affordances and the four determinants. Subsequently, a redundancy analysis (RDA) and variation partition analysis (VPA) were conducted to calculate determinants’ total, joint, and independent effects. Finally, after extracting the map data without any recorded behaviours, a multiple factor analysis (MFA) was utilised to reveal the potential constraints for affordance actualisation. All analytic procedures were constructed in R version 4.0.3. The packages of linkET (Huang, 2021), dplyr (Wickham et al., 2020) and ggplot2 (Wickham, 2016) were employed for calculating and visualising the results of the Mantel Test. The RDA and VPA were performed with the vegan package (Oksanen et al., 2019), and the MFA results were presented by the FactoMineR (Husson et al., 2008) and visualised by the factoextra (Kassambara & Mundt, 2020). Figure 2 illustrates the workflow of this research.

### 3 Results

Based on the mapping results of the seven rest area sites, we firstly clarified the affordances of general features from taxonomic, spatial, and temporal perspectives. After that, we verified the conceptualised determinants of affordances actualisation and calculated their effects. Finally, we extracted the none affordance areas to reveal the descriptors that cause actualisation vacancy.

#### 3.1 Taxonomic, spatial, and temporal features of affordances

The affordance taxonomy of rest areas is presented with the coding results of on-site observations. After 8 hours of observation on the sites, we collected a total of 6194 individual behaviours, classified in 15 types (Table 1). The affordance of photography, walking, lookout, and sitting account for more than 10% of the total and are the most common affordances in scenic road rest areas. On the opposite side, the affordance of hand-washing, bicycle parking, and climbing contributed less than 1% of the total, and could be classified as occasional activities during the investigation.

<table>
<thead>
<tr>
<th>Affordance type</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Site 5</th>
<th>Site 6</th>
<th>Site 7</th>
<th>Sum</th>
<th>Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affords bicycle parking</td>
<td>5</td>
<td>19</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>41</td>
<td>0.66</td>
</tr>
<tr>
<td>Affords bicycle rental</td>
<td>84</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>84</td>
<td>1.36</td>
</tr>
<tr>
<td>Affords car parking</td>
<td>81</td>
<td>29</td>
<td>50</td>
<td>46</td>
<td>126</td>
<td>18</td>
<td>10</td>
<td>360</td>
<td>5.81</td>
</tr>
<tr>
<td>Affords climbing</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>17</td>
<td>0</td>
<td>27</td>
<td>0.44</td>
</tr>
<tr>
<td>Affords cycling</td>
<td>143</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>143</td>
<td>2.31</td>
</tr>
<tr>
<td>Affords hand-washing</td>
<td>53</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>54</td>
<td>0.87</td>
</tr>
<tr>
<td>Affords interpretation</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>97</td>
<td>9</td>
<td>0</td>
<td>106</td>
<td>1.71</td>
</tr>
<tr>
<td>Affords lookout</td>
<td>453</td>
<td>5</td>
<td>114</td>
<td>45</td>
<td>30</td>
<td>143</td>
<td>56</td>
<td>846</td>
<td>13.66</td>
</tr>
<tr>
<td>Affords meals or snacks</td>
<td>255</td>
<td>116</td>
<td>0</td>
<td>0</td>
<td>85</td>
<td>0</td>
<td>4</td>
<td>460</td>
<td>7.43</td>
</tr>
<tr>
<td>Affords photography</td>
<td>538</td>
<td>7</td>
<td>147</td>
<td>95</td>
<td>165</td>
<td>258</td>
<td>189</td>
<td>1399</td>
<td>22.59</td>
</tr>
<tr>
<td>Affords refuelling</td>
<td>0</td>
<td>62</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>62</td>
<td>1.00</td>
</tr>
<tr>
<td>Affords shopping</td>
<td>116</td>
<td>30</td>
<td>11</td>
<td>13</td>
<td>50</td>
<td>22</td>
<td>19</td>
<td>261</td>
<td>4.21</td>
</tr>
<tr>
<td>Affords sitting</td>
<td>462</td>
<td>37</td>
<td>16</td>
<td>1</td>
<td>87</td>
<td>15</td>
<td>4</td>
<td>622</td>
<td>10.04</td>
</tr>
<tr>
<td>Affords using toilet</td>
<td>245</td>
<td>53</td>
<td>42</td>
<td>0</td>
<td>59</td>
<td>0</td>
<td>0</td>
<td>399</td>
<td>6.44</td>
</tr>
<tr>
<td>Affords walking</td>
<td>933</td>
<td>42</td>
<td>60</td>
<td>43</td>
<td>179</td>
<td>61</td>
<td>12</td>
<td>1330</td>
<td>21.47</td>
</tr>
<tr>
<td>Sum</td>
<td>3368</td>
<td>400</td>
<td>456</td>
<td>249</td>
<td>883</td>
<td>543</td>
<td>295</td>
<td>6194</td>
<td>100</td>
</tr>
</tbody>
</table>

Given the temporal feature of the observed behaviours, we recorded the number of ongoing activities every half hour to better understand the shifting tides of affordance actualisation. As shown in Fig. 3, the affordance actualisation on each site has generally experienced an increase and a decline in the morning and the late afternoon. However, the rising or falling trend is rather random when observations are accurate to the hour. This phenomenon indicates that there is no strict time pattern for the usage of scenic road rest areas.
To better analyse spatial patterns, we recorded the position of the observed behaviours on each site and calculated the mean coordinates according to the affordance type feature using QGIS. Then, we adopted the linear distance matrix algorithm on those mean coordinates to explore whether there are spatial connections between different affordances. The result showed that the affordance of cycling, bicycle rental, toilet use, refuelling, and having meals or snacks are rather independent since their mean distances are all higher than the average level (36.60 m) of all types of affordances. On the other hand, the affordance of interpretation, climbing, sitting, walking, shopping, lookout, photography, and car parking are interrelated. Their mean distance is close and all below the average level.

### 3.2 Correlations between determinants and actualised affordances

The hexagonal grids containing at least one actualised affordance were selected for analysis to testify the validity of the four conceptualised determinants in affordances actualisation. We applied the Mantel Test to calculate the matrix correlations between descriptors and the actualised affordances. Considering that differences in environment or behaviour settings among the selected sites may lead to stratification of observed data and thus influence the results of the Mantel Test, we conducted seven separate tests for each site.

Figure 5 illustrates the correlations between determinants and individual/all behaviours. Considering the individual affordance taxonomy, albeit different behaviours correlated with the determinants in various ways, it was detected that the affordance of car parking, sitting, walking, photography, shopping, meals or snacks were relevant to the determinants at least 6 times, indicating that those behaviours can be mostly explained by the determinants. The determinant of Perceived Use Patterns was statistically relevant to 20 behaviours on all sites. Fixed Functional Meanings, Surface Materials, and Distance References were also relevant to 18, 12 and 6 behaviours respectively. According to the results of the Mantel Test between determinants and all recorded behaviours, Perceived Use Patterns has strong correlations with the actualised affordances in all sites; its Mantel's *r* reached a high level between 0.2317 and 0.7544. It was also determined that Fixed Functional Meanings is correlated with affordance actualisation in five sites in general, as the Mantel's *r* ranged from 0.1002 to 0.3084. In addition, Surface Materials has valid correlations in three sites, and its Mantel's *r* varied from 0.0820 to 0.5130. Finally, Distance References turned out to have general correlations in only two sites, with Mantel's *r* ranging from 0.0657 to 0.2239.

### 3.3 Total, joint, and independent effects of determinants

To investigate and quantify which of these determinants have a stronger impact, we employed RDA and VPA to explore the regression models between determinants and affordance actualisation. The total effects of all determinants are presented by the results of the adjusted $R^2$ in RDA. As shown in Table 2, the adjusted $R^2$ varied between 0.5999 and 0.9508. This result indicated that although the determinants' total effects are different in each site, these determinants explain many of the outcomes regarding affordance actualisation.

<table>
<thead>
<tr>
<th>Site</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Site 5</th>
<th>Site 6</th>
<th>Site 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.6578</td>
<td>0.8853</td>
<td>0.8837</td>
<td>0.9745</td>
<td>0.8551</td>
<td>0.8925</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.6288</td>
<td>0.8155</td>
<td>0.7303</td>
<td>0.9508</td>
<td>0.8191</td>
<td>0.7237</td>
</tr>
</tbody>
</table>

The joint and separate effects of each determinant are presented by the variation partitioning diagram in VPA (Fig. 6). Again, the joint and independent effects of determinants vary considerably according to each site due to the different environments and behaviour settings. However, we have also identified some patterns that are worth addressing. The Perceived Use Patterns independently explained up to 51.30% of the variance in affordance actualisation, and jointly explained at most 34.29% of the variance with other determinants. Fixed Functional Meanings independently accounted for 41.19% of the total variance, while jointly explained at most 33.69% of it. Distance References independently and jointly explained up to 8.36% and 34.29% of the variance, respectively. Finally, Surface Materials explained up to 7.04% independently and 26.66% jointly of the variance. These results indicated that Perceived Use Patterns and Fixed Functional Meanings tend to independently influence the actualisation of affordances, while Distance References and Surface Materials tend to jointly affect affordance actualisation with other determinants.

### 3.4 Affordance actualisation vacancy

The gridded maps revealed some vacant spots without any recorded activity, and the attributes of these grids could help us investigate the vacancy of affordance actualisation. The MFA was employed in this section to clarify how are the determinants and their descriptors responsible for the actualisation vacancy. Due to the absence of ongoing behaviour in these grids, there is no perceived use pattern recorded on the map. Therefore, the MFA is only suitable for discussing the matrices of Surface Materials, Fixed Functional Meanings, and Distance References.

As shown in Fig. 7, the first two axes of the MFA explained 20.77% and 14.56% of the total variance. The first axis was linked dominantly to Surface Materials and Fixed Functional Meanings, and the second axis was concerned with all of the three determinants. In particular, the descriptor of Greening, Asphalt, Carriageway, Shrub, Natural environment, Distance to parking, centroid, entrance and roadway, significantly contributed to the variance. These results implied that the places with automobile driveways, inaccessible green spaces, and too far away from the centre or parking lots are restraining the diverse usage of scenic road rest areas.

### 4 Discussion
Using behaviour mapping data of seven rest areas on the Nujiang Beautiful Road in southwest China, this study explored how motorists interact with the landscapes of the rest areas on scenic roads through the lens of affordance theory. After generalising the maps of the case sites into lattices of hexagonal grids, we recorded the behaviours occurring within the grid cells, and extracted their different properties according to the theoretical framework. The processed data has gone through a series of statistical analyses, including the Mantel Test, RDA, VPA, and MFA. This empirical approach allowed us to verify and quantify the relations and impacts of the determinants on affordance actualisation in the context of rest area usage.

4.1 The behavioural profile of rest area usage on scenic road

The general features of the recorded affordances outlined a basic profile of the rest area usage on scenic road. The affordance actualised within the rest areas has not shown any noticeable temporal pattern. This result confirmed Denstadli and Jacobsen's (2011) assertion regarding the intention of recreational driving to be enjoyed freedom from the constraints of timetables. In addition, Heft's affordance taxonomy provides a functional approach to environmental description that help us better understand the behaviour settings of different places (Clark & Uzzell, 2002; Heft, 1988; Qi et al., 2021). In this case study, the affordance taxonomy mainly includes 15 types of behaviours, and their combinations reflected how rest areas are used by motorists. Photography, walking, lookout and sitting, which accounted for more than two-thirds of all collected data, are the most predominant affordances. The distance matrix showed that these affordances are spatially close to each other, and all of them are characterised with recreational meanings. The remaining affordances were those with mainly planned and anticipated purposes, e.g., car parking, having meals or snacks, using toilet, shopping, or refuelling. These affordances are spatially more independent, and highly adhere to corresponding spots or facilities. Through these results, we could identify two potential categories that can be conceptualised in the affordance taxonomy.

- (i) Inspired affordance: refers to individuals’ impulsive activities that can be inspired by surrounding environmental opportunities. For example, a good viewpoint inspires people to lookout or photography, and a fascinating trail invites people to explore the path.
- (ii) Anticipated affordance: refers to individuals seeking environmental opportunities to carry out their pre-set intentions. For instance, motorists who have the intention to park and have meal would search for suitable places that afford parking and serve quality food.

This taxonomy is aligned with the theory of Recreation Opportunity Spectrum (ROS), which has been widely adopted to assist landscape planning and management. It is commonly acknowledged that a diverse taxonomy or ROS could help recreationists construct their personal quality experiences (Harshaw & Sheppard, 2013). Nevertheless, the inspired affordances are more spatially consistent and account for a large proportion of activities in the case. They underlined the spontaneous usage of affordances that stimulate the so-called ‘behavioural insideness’, a deeper attachment of individuals to their interacting landscapes that brings immersive experiences (Laaksoharju & Rappe, 2017). Therefore, the inspired affordances should be considered a priority resource compared with those anticipated in outdoor recreation. Rather than listing the general ROS of the landscape, we encourage planning and design practices to shift focus on how inspired affordances can be actualised more, even though this is more of an open-ended question in recreational driving and other similar human-landscape interaction contexts.

4.2 Physical and perceptual dimensions in affordance actualisation

Affordances are defined as both objective properties and psychological significance linked to relations between individuals and their environment (Heft, 2010). Consequently, the determinants of affordance actualisation derive from both physical and perceptual dimensions (Ackerman, 2019). Many studies have already emphasised this physical-perceptual relationism (Aradi et al., 2016; Araújo et al., 2019; Lennon et al., 2017; Rietveld & Kiverstein, 2014), but how they separately and collectively affect affordances is yet to be revealed. Therefore, considering the context of rest area usage, we encapsulated Surface Materials and Distance References as physical attributes of the landscapes, and Fixed Functional Meanings and Perceived Use Pattern as perceptual factors of people to investigate how the physical and perceptual determinants cooperate in actualising the affordances of landscapes.

The first relevant finding we present is that, despite the four determinants being generally valid in affordance actualisation, not all of them acted persistently in each site. In other words, some determinants may be absent given the different landscapes and behavioural settings. Among the four determinants, Perceived Use Pattern seems to be the most powerful and stable one since it explained most actualised affordances in most sites. Fixed Functional Meanings is also linked to a large proportion of affordances in many sites, coming as second most relevant to this context. According to Raafat et al. (2009), the way people use the environment is driven by the ‘herding instinct’ that can arise when we take the chance to visit an unfamiliar place. If some references regarding a place are absent, then choices have to be made according to each individual's understanding. In this case, the perspective of affordance delivered an explanation of this phenomenon. Other people's usage provided direct information about affordances of the environment for individuals. Therefore, homogeneous affordances are easy to be actualised. In another way, people's cognitions and past experiences also deliver crucial messages regarding a site's affordances, hence encouraging the process of actualisation more independently.

As the physical dimension, Surface Materials and Distance References also responded to the actualisation in many sites. Several affordance studies have also highlighted that the materials of the landscapes or environments (Bozkurt et al., 2019; Fjortoft et al., 2009; Laaksoharju & Rappe, 2017; Lennon et al., 2017) and distance to places with particular significances (Aradi et al., 2016; Fusco, 2016; Kytta et al., 2018) are proper explanations for the type and frequency of landscape usage. But unlike the perceptual dimension, the VPA showed that Surface Materials and Distance References outstood for their joint effects associated with the perceptual determinants. This result implies that the physical and perceptual dimensions might not be parallel to each other. Although physical attributes of the landscapes provided both opportunities and obstacles for behaviours, people could overcome physical difficulties within expectation to carry out their intended activities, all of that based on their personal judgment. Hence, it is concluded that perceptual dimension is more likely to play a leading role in human-landscape interaction in this case.

4.3 Constraints of motorists-rest area interaction
The affordance framework outlined the conveniences for a range of actions and associated constraints (Buckley & Akhoundogli, 2019; Kaaristo & Visentin, 2022). In this study, the detected actualisation vacancy provided some clues to interpret affordance constraints in the areas included as research objects. The result of MFA demonstrated that the material of asphalt and the functional meaning of carriageway stand out as descriptors of the traffic environment that ascribe to the vacancy. As Ackerman (2019) stated, traffic close to the site might be a negative affordance for recreational visitors to experience their destinations. When confronted with the pedestrian-vehicle conflicts, people are more likely to give way to vehicles in shared spaces without traffic signs (Kaparias et al., 2015) so, naturally, the diverse usage of roadway in or close to the rest areas is negatively affected.

Another constraint from the MFA is the designed green space, which is consisted by the functional meaning of greening, and the materials of shrub and grass. Kaparias et al. (2015) explain that landscape usage by recreationists is shaped by availability. Compared with the hardscapes, green spaces with grassland and shrubs discouraged affordance actualisation by delineating spatial boundaries. However, we have also noticed that the outcomes of the behaviour mapping recorded many activities outside but close to the green spaces. This result denoted that rather than afford behaviours per se, green spaces stimulated the discovery and usage of affordances beyond their boundaries. The descriptor of natural environment presented a similar situation. Although previous studies concluded that natural environments are generally rich in affordances (Fjørtoft et al., 2009; Fjørtoft & Sageie, 2000; Gulwadi et al., 2019), our results showed that natural environments somehow reject inside activities while attracting affordances outside the boundaries. Fences, shrubs, terrains, and other design language produced enclosed spaces of rest areas, sending a message to people not to step out in nature. As aforementioned in the introduction, the aim of scenic road rest areas is not to create urban park-like service bays but to provide stages for motorists to interact with nature. This finding indicates that the design of the case sites needs to rethink strategies that invite people to explore the natural landscape along the scenic road.

Finally, Distance References, particularly the distance to parking areas, also responded to unused affordances of rest areas. Edensor (2006) claimed that affordances are spatial potentialities that constrain and enable a wide range of actions. In previous studies focused on environments for children and adolescents’, home and school were highlighted as important references for the exploration and utilisation of affordances (Aradi et al., 2016; Kyttä et al., 2018). In the context of recreational driving, parking areas are identified as critical references for the actualisation of various affordances. This outcome reminds us that the whole behaviour setting of scenic road usage, including the parts where drivers pull over to relax, is essentially vehicle-based. This conclusion might bring some new insights that are useful to upgrade and modernise the design of spatial layout for rest areas.

5 Conclusion

The development of scenic roads is world-wide implemented as a strategy to integrate tourism and transportation and convert automobility into landscape capital. Since rest areas along scenic roads offer opportunities for motorists to engage with the landscape beyond the windshield, the mechanism of this human-landscape interaction plays an essential role in scenic road systems. Through the lens of affordance theory, this study presented an empirical approach to explore how affordances are actualised by people in scenic road rest areas. The affordance taxonomy and spatiotemporal features unveiled by our research can help understand the behaviour setting of recreational driving, providing a rudimentary guideline for the planning and design of rest areas.

Beyond that, some of our findings about the mechanism of affordance actualisation may require additional attention. In the context of rest area usage, the affordances could be deconstructed as inspired and anticipated affordances. The difference between these two types relies on the fact that the former links with recreationists’ impressive and quality experiences while the latter denotes their satisfaction on reception-related needs. Furthermore, our results also showed that the affordance actualisation process is affected by determinants of both physical and perceptual dimensions, but the determinants of perceptual tend to take a more proactive position, resulting in the unparallel status of these two dimensions. Moreover, our outcomes also showed that carriageways, site greening, natural environments, and parking areas nearby or inside the rest areas played key roles in scenic road systems since their features could significantly encourage or discourage the actualisation of diverse affordances regarding the levels of engagement with roadside landscape. On the one hand, the above conclusions would help to deepen the affordance theory by quantifying its actualisation determinant and vacancy, unveiling the nonparallel effects of physical and perceptual dimensions that act on affordance usage. On the other hand, our empirical results highlight the importance of inspired affordances, vehicle-based principles, and landscape availability for rest areas. It is expected that these implications could enlighten the planning and design practices of scenic roads and their rest areas.

Finally, it is equally important to acknowledge the limitations of our study. Firstly, since we only chose a peak tourist period to conduct the investigation, we could not examine how rest areas are used off-season and whether there are relevant differences in off-peak periods of the year. Secondly, rest areas could be further classified into different types according to size, facilities, landscapes, and other features. However, due to the lack of sufficient samples of the same type, we have not explored how the usage of different types of rest areas affects the experience of motorists on scenic roads. These limitations represent promising perspectives for future related research.

Declarations

Author Contributions

All authors contributed to the study conception and design. Methodology, data collection and analysis, visualization, original draft, reviewing and editing were managed by Jun Qi. Xueqiong Tang contributed to the conceptualisation, review, editing and supervision.

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**Competing interests**

The authors have no relevant financial or non-financial interests to disclose.

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**Figures**
Figure 1

Locations and general features of the seven sites investigated along Nujiang Beautiful Road in northwest Yunnan, China.
Figure 2

Study workflow
Temporal features of actualised affordances showed no strict pattern except an increase in the morning and a decrease in the late afternoon. Line colour represents the type of observed behaviour, column in waterfall plot records the increase or decrease in the number of people engaged in all behaviours.

Figure 3
Figure 4

Spatial features of actualised affordances. The value in the bracket indicates the average distance (m) from the mean coordinate of a given behaviour to others.
Figure 5

Pairwise comparisons of Mantel Test, lines/dots help visualise Mantel's correlations between determinants and individual/all behaviours, line width and dot size represent Mantel's r for correlations, and the colour corresponds to the significance. Pearson correlation between each behaviour is also calculated and visualised with a colour gradient.
VPA quantified the determinants' independent and joint effects (%) on affordance actualisation. Variance contributions above 10.00% are marked in red.

Correlation and contribution (to the first two axes) graphs for the first 20 descriptors of affordance determinants that resulted in actualisation vacancy.