

Homeliness in Elderly Care Facility Interiors: Older Adults' Visual Attention and Environmental Appraisal

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Abstract

As elderly care facilities shift from institutionalized care toward more home-like living environments, enhancing interior homeliness is increasingly important for older adults' living experience. This study examined residential, communal activity, and circulation spaces in elderly care facilities. Thirty older adults participated in eye-tracking and homeliness evaluations, and 45 representative scenes with high, medium, and low homeliness were selected for environmental perception assessment. Areas of interest (AOIs) were defined to extract total fixation duration (TFD), fixation count (FC), and revisit count (RC), combined with group comparisons, correlation analyses, heatmaps, and scanpaths. Results showed no significant differences in overall eye-tracking metrics among homeliness groups, indicating that homeliness cannot be inferred from total visual attention alone. Instead, differences were mainly reflected in attention targets and allocation patterns. High-homeliness scenes were associated with domestic, natural, and decorative cues, whereas low-homeliness scenes were more influenced by functional, barrier-free, and interface elements. Environmental perception further confirmed that greater visual attention does not necessarily indicate positive preference. This study proposes a multilayer framework integrating eye tracking, homeliness evaluation, environmental perception, and image-based evidence to support home-like design in elderly care facilities.

1. Introduction

1.1 Elderly care facilities: from care settings to long-term living environments

Population ageing has become an increasingly important challenge for urban planning and the provision of social infrastructure. As cities expand elderly care services, planning has traditionally focused on the spatial distribution, accessibility, capacity, and service provision of care facilities. However, the quality of age-friendly urban infrastructure depends not only on whether older adults can access services, but also on how they experience the environments in which care and everyday life take place. Elderly care facilities in China are undergoing a fundamental transformation in their functional role, gradually shifting from short-term care settings centered on medical and nursing services to long-term living environments where older adults spend their later years (Zhou and Feng, 2023). Older adults' recognition of and sense of belonging to their living environments and places are rooted in their perceptions of past living experiences and tend to strengthen with age and accumulated life experience. This requires elderly care environments to be consistent with their familiar lifestyles (Hu and Ye, 2020). Within these facilities, spatial organization, furniture arrangement, material and color schemes, and the creation of everyday activity settings affect not only operational efficiency and user safety, but also older residents' ability to maintain autonomy, preserve their sense of identity, and develop emotional attachment to the environment (He et al., 2024; Chaudhury and Xu, 2022). The competence-press model, a core theory in environmental gerontology, suggests that the fit between individual competence and environmental demands influences older adults' behavioral adaptation and living experience (Lawton and Nahemow,

1973). When environmental demands are well matched to individual competence, older adults are more likely to maintain higher levels of autonomy and life satisfaction; conversely, a poor fit may lead to maladaptation, negative emotional states, and functional decline. Therefore, the design of contemporary elderly care facilities should move beyond merely meeting regulatory requirements and facilitating care management. It should also address the deeper psychological needs of older adults and consider whether they can develop a “homeliness” living experience within institutional environments (Blackler et al., 2023).

1.2 Homeliness in the interior spaces of elderly care facilities

Homeliness is a complex subjective experience jointly shaped by psychological perceptions, social relationships, and the physical environment (He et al., 2026). It is not simply created by replicating residential forms or domestic decorative elements, but emerges through the continuous interaction of older adults with physical spaces, everyday activities, and social relationships (Rijnaar et al., 2016; Coonery, 2012; Johansson et al., 2022). It encompasses multiple dimensions, including familiarity and comfort, autonomy and control, continuity of personal identity, social connection, and emotional belonging (Van Hoof et al., 2016; Bae and Kim, 2024). Overall, homeliness in elderly care facilities is mainly influenced by four aspects: residents’ psychological factors, social relationships, the architectural environment, and organizational management. Recognition and respect, continuity of habitual lifestyles, autonomy and control, and comfort all influence residents’ sense of homeliness (Rijnaar et al., 2016). Social relationships, daily interactions, and the physical environment are not independent of one another but collectively contribute to the homeliness in elderly care facilities; factors such as privacy, personalized spaces, and social connections all influence residents’ experience of “home.” (Lee et al., 2022). By respecting residents’ individual life experiences and habits, caregivers help older adults reestablish a homeliness in a residential care setting by maintaining their autonomy, family connections, and daily activities, and by supporting the personalization of their living spaces (Materese et al., 2022). Views from windows, accessibility, personal belongings, and interior design also serve as important environmental cues through which older residents develop a sense of homeliness (Blackler et al., 2023; Matarese et al., 2022). In addition to psychological and social factors, the architecture and design of elderly care facilities have a profound influence on residents’ sense of homeliness. Eijkelenboom investigated which architectural factors contribute to the creation of homeliness and incorporated these findings into design guidelines (Eijkelenboom et al., 2017). Autonomy, meaningful social connections, and personalized environments are essential for creating a home-like living environment for long-term residents (Gan et al., 2025). Existing studies have primarily used questionnaires (Chen and Zhou, 2022), interviews (Zhou and Li, 2018), the semantic differential method (Luo and Chen, 2020), and restorative evaluations (Wang and Zhou, 2025) to examine older adults’ subjective perceptions of spatial comfort, safety, warmth, autonomy, and sense of belonging. Although these methods can directly capture users’ overall perceptions, they provide limited insight into which specific spatial contents older adults attend to when forming judgments of homeliness. They also make it difficult to determine whether the objective presence of a spatial element actually enters older adults’ perceptual and cognitive processes.

1.3 Eye-tracking experiment and spatial environmental perception assessment

Eye-tracking can accurately capture and record visual behavior parameters, such as fixation location, fixation duration, and fixation count, while participants view images of spatial environments. It has become an important quantitative method in architectural and environmental perception research for revealing patterns of visual attention and selection (Bao et al., 2024). Among the commonly used metrics, total fixation duration (TFD) indicates the overall amount of visual attention allocated to a specific region, fixation count (FC) reflects the frequency with which that region attracts visual attention, and revisit count (RC) describes the tendency of participants to return their gaze to a target region after looking away. Together, these three metrics provide a basic framework for characterizing visual attention to spatial environments (Dupont et al., 2024). Area of interest (AOI) analysis further links eye-tracking events to specific spatial elements, thereby transforming information about “where older adults look” into comparable quantitative data.

Meanwhile, spatial environmental perception questionnaires can capture how older adults evaluate environmental attributes such as spatial scale, function, furniture, materials, colors, greenery, practicality, and aesthetics, thereby revealing “how the attended environment is subjectively perceived.” Combining these two approaches enables objective data on visual attention to be examined alongside subjective evaluations of environmental perception, allowing the two sources of evidence to complement and validate each other (Xiao et al., 2025).

It should be emphasized that eye-tracking metrics essentially reflect the distribution of visual attention and cannot be directly interpreted as indicators of liking or preference. Longer fixation durations may result from interest, familiarity, or positive attraction, but they may also be caused by visual incongruity, difficulty in understanding, negative emotional responses, or the absence of other visually salient elements in the scene (Li et al., 2026). Similarly, heatmaps and scanpath plots should be interpreted in conjunction with the original images, the semantic meaning of the AOIs, and the results of the spatial environmental perception assessment.

1.4 Research gaps and research questions

Overall, existing research on homeliness in elderly care facilities still has four major limitations. First, existing evidence relies heavily on subjective descriptions with limited real-time visual behavior data from older adults. Second, the few eye-tracking studies in architectural research often interpret fixation duration directly as preference, overlooking that greater attention may result from visual incongruity, functional recognition, or the absence of other salient targets. Third, eye-tracking metrics alone cannot determine whether attention has positive or negative meaning and require integration with environmental assessments. Fourth, studies generally discuss homeliness at the overall environment level, with limited attention to differences among residential, communal, and circulation spaces, and fine-grained analyses

linking homeliness to specific elements remain insufficient. Accordingly, this study addresses the following research questions:

RQ1: Do overall TFD, FC, and RC differ among the high-, medium-, and low-homeliness groups across the three types of spaces? Can homeliness be determined solely by the overall amount of visual attention?

RQ2: Across different space types and levels of homeliness, how is older adults' visual attention distributed among major AOI categories, including domestic, natural, decorative, social, barrier-free, and spatial interface elements? Do high-homeliness spaces exhibit different patterns of attention distribution from low-homeliness spaces?

RQ3: Which specific AOI elements show significant correlations between their TFD, FC, and RC values and homeliness scores?

RQ4: Which attributes in the spatial environmental perception questionnaire are associated with homeliness scores, and how can these perceptual evaluations further explain eye-tracking patterns to distinguish positive attraction from negative salience?

This study further decomposes the overall subjective evaluation of homeliness into visual attention directed toward specific spatial elements. By demonstrating that similar overall levels of visual attention may correspond to different spatial meanings, it provides a more detailed understanding of the mechanisms underlying the formation of homeliness. A multilayer evidence-triangulation framework integrating eye-tracking metrics, homeliness evaluation, environmental perception assessment, and image-based evidence is established. Eye-tracking data are used to identify patterns in the distribution of visual attention, environmental questionnaires are used to interpret subjective evaluations of the elements receiving attention, and homeliness questionnaires are used to capture the overall emotional experience. This framework helps avoid the common misconception that "longer fixation" necessarily means "greater preference" and provides a methodological reference for multilevel evidence integration in research on environmental perception in elderly care settings. The findings can further be translated into home-like design strategies for residential spaces, communal activity spaces, and circulation spaces in elderly care facilities. By providing designers with specific recommendations grounded in evidence from older adults' visual behavior and environmental perception, this study aims to support the continuation of personal lifestyles and the development of emotional belonging within institutional environments.

2. Materials and methods

2.1 Experimental design

The research framework is shown in Fig. 1. The first stage consisted of an eye-tracking experiment and image-based homeliness evaluation. After collection and screening, the interior images of elderly care facilities were stratified by space type and divided into six groups. Each participant completed the eye-

tracking experiment for all images across six sessions and rated the homeliness of the images immediately after each mini-block. After homeliness ratings had been obtained for all 308 images in the first stage, the images were independently ranked within each space type according to their mean homeliness scores. Candidate images were identified from the lowest 30%, middle 40%, and highest 30% of the score distribution. From each range, five representative images of low, medium, and high homeliness were selected based on image clarity, spatial representativeness, and suitability for AOI annotation. This resulted in a total of 45 core images for analysis, comprising three space types-three homeliness levels-five images (Fig. 2).

In the second stage, a 11-item spatial environmental perception questionnaire was administered only for these 45 representative images to further explain the specific environmental factors associated with high and low levels of homeliness. The 45 representative images were then used as the primary analytical dataset. Overall eye-tracking metrics, AOI-based eye-tracking metrics, homeliness scores, and spatial environmental perception ratings were integrated for descriptive statistics, Kruskal-Wallis tests, Spearman correlation analyses, and false discovery rate (FDR) correction for multiple comparisons. The quantitative results were further interpreted in conjunction with the original images, AOI-labeled images, heatmaps, and scanpath plots.

2.2 Participants

Older adults were recruited through open recruitment in local communities. Due to practical constraints, residents currently living in elderly care facilities were not recruited; therefore, all participants were community-dwelling older adults. The inclusion criteria were as follows: ≥aged 60–80 years; ≥normal cognitive function, with the ability to independently understand the experimental tasks, view the images, and complete the questionnaires; ≥normal or corrected-to-normal vision, without visual impairments such as colour vision deficiency or colour blindness that could interfere with image recognition; ≥voluntary participation in the study with written informed consent. The exclusion criteria included severe psychiatric disorders, severe cognitive impairment, or ocular diseases that prevented successful eye-tracking calibration or completion of the image-viewing tasks.

A total of 35 older adults were initially recruited. After eye-tracking calibration and the formal experiment, participants with failed calibration, an insufficient proportion of valid fixation data, or substantial missing data for key experimental variables were excluded. Ultimately, data from 30 valid participants were included in the subsequent analyses.

2.3 Image collection and grouping

In the preliminary study, a database of 370 interior images of elderly care facilities was established, from which 308 images were selected for the subjective evaluation and eye-tracking experiment in the first stage (Table 1). Image selection was primarily based on the following criteria: ≥Image quality: images with clear resolution, balanced exposure, and no obvious occlusion or distortion were retained; ≥Completeness of spatial information: priority was given to images that clearly presented

spatial layout, furniture arrangement, interface characteristics, and the overall environmental atmosphere; Visual recognition and experimental suitability: scenes with clearly identifiable spatial functions that could be readily recognised by older participants were retained; Sample representativeness and balance: candidate images were manually screened according to the proportions of the three functional space types to ensure sufficient diversity in spatial scale, furniture configuration, decorative characteristics, and everyday activity settings.

Because viewing all 308 images in a single session would impose a substantial fatigue burden on older participants, the images were first stratified and randomized according to three space types—residential spaces, communal activity spaces, and circulation spaces—and were then proportionally and evenly allocated to six stimulus groups (A-F) based on the distribution of each space type in the full sample. Each group contained 51–52 images (Table 2). All six stimulus groups included images from the three space types, with the composition of space types kept as consistent as possible across groups. Each valid participant completed all six stimulus groups. Consequently, all 308 images ultimately received eye-tracking data and homeliness ratings from the same group of valid participants.

Table 1
Image collection and screening

Spacial type	Total database	Images collect	After screening	Total
Resident spaces	370 images	110	89	308
Communal activity spaces		140	122	
Circulation spaces		120	97	

Table 2
Experiment groups

Group							Images
1	A	B	C	D	E	F	52
2	B	C	D	E	F	A	51
3	C	D	E	F	A	B	51
4	D	E	F	A	B	C	52
5	E	F	A	B	C	D	51
6	F	A	B	C	D	E	51

2.4 Eye-tracking experimental procedure

The experiment was conducted in a relatively quiet indoor environment with stable lighting conditions. Gaze data were recorded using an aSee A6 desktop eye tracker. To control for potential learning, fatigue, and order effects arising from repeated experimental sessions, the presentation order of the six stimulus

groups (A-F) was counterbalanced using a Latin square design. The 30 participants were evenly assigned to six presentation sequences, with five participants in each sequence. The six experimental sessions were conducted at separate times rather than consecutively within a single period, thereby reducing fatigue and calibration drift caused by prolonged viewing of all 308 images.

The experimental procedure is shown in Fig. 3. Eye-tracker calibration was performed before each experimental session. Before each spatial image was presented, a fixation point appeared at the center of the screen for 1 s, followed by the spatial image for 15 s and then a blank screen for 0.5-1 s as the interstimulus interval. Each stimulus group was divided into three mini-blocks, with approximately 17 images in each mini-block. A 1–2 min break was provided between mini-blocks, and recalibration was performed when changes in head position, gaze drift, or reduced recording quality were observed. Images were presented in a randomized order within each mini-block. During the eye-tracking phase, participants were instructed only to view the images freely and did not complete questionnaires simultaneously. After each mini-block, the images that had just been viewed were presented again for homeliness evaluation. This block-based design was adopted to minimize the effects of prolonged continuous viewing on older participants' attention levels and the quality of the eye-tracking data.

2.5 Indicator extraction

2.5.1 Eye-tracking metrics

Eye-tracking data were collected using an aSee desktop eye tracker while participants viewed interior spatial scenes of elderly care facilities. The raw eye-tracking data were preprocessed through outlier removal, drift correction, and data alignment. This study focused on total fixation duration (TFD), fixation count (FC), revisit count (RC), eye-tracking heatmaps, scanpath plots, and area-of-interest (AOI) data.

2.5.2 Areas of interest

AOIs were manually annotated based on the functional semantics of elderly care spaces and visually identifiable elements within each image. To enable conceptual comparisons across the three space types, specific spatial elements were grouped into six major categories: A, domestic elements; B, natural elements; C, decorative elements; D, social elements; E, barrier-free elements; and F, spatial interface elements (Table 3). Because the specific elements represented in each space type were not entirely identical, the analysis first compared the broader semantic AOI categories and then interpreted the results at the level of specific elements within their corresponding image and spatial contexts.

Table 3
Semantic classification of areas of interest (AOIs)

AOI	Core meaning	Residential spaces	Communal activity spaces	Circulation spaces
A. Domestic	Everyday living, rest, and traces of personal life	Bed, wooden furniture, sofa, personalised belongings	Wooden furniture, sofa, personalised belongings	Wooden furniture, resting furniture, personalised belongings
B. Natural	Connection with nature and the outdoors	Greenery, window views		
C. Decorative	Decoration, aesthetics, and visual stimulation	Artwork, lighting fixtures, decorative objects		
D. Social	Social interaction, activities, and shared-living settings	Table-and-chair arrangements, television	Table-and-chair arrangements, television, activity facilities	Table-and-chair arrangements or short-stay facilities
E. barrier-free	Care, safety, and assistive functions	Handrails, wheelchairs, care facilities	Handrails, wheelchairs, care facilities	Handrails, wheelchairs, care facilities
F. Spatial Interface	Spatial boundaries, partitions, and wayfinding	Doors and windows, partitions	Doors and windows, partitions	Signage, spatial interfaces, and wayfinding elements

2.6 Subjective questionnaire design

2.6.1 Homeliness questionnaire

Homeliness was conceptualized as an overall experience comprising nine affective dimensions (He et al., 2026) and was used to assess the overall emotional response elicited by the 308 images in the first stage. To avoid altering participants' free-viewing strategies by inserting questionnaire items during image viewing, subjective ratings were not collected simultaneously with the eye-tracking task. A four-point Likert scale was used, with a score of 1 indicating a very weak feeling or complete disagreement and a score of 4 indicating a strong feeling or strong agreement. The ratings of the 30 valid participants were then averaged to obtain an image-level homeliness score. A higher score indicated a stronger sense of homeliness elicited by the image.

2.6.2 Spatial environmental perception questionnaire

To further explain the environmental characteristics underlying different levels of homeliness, a spatial environmental perception questionnaire was developed based on the image-based homeliness evaluation conducted in the first stage. Whereas the homeliness questionnaire assessed the overall

emotional experience elicited by a space, the spatial environmental perception questionnaire was designed to identify which specific environmental attributes influenced older adults’ spatial perceptions, thereby providing an environmental explanation for the observed patterns of visual attention. The questionnaire framework was developed with reference to studies on environmental psychology, age-friendly environmental assessment, and interior design of elderly care facilities. Key attributes affecting older adults’ environmental experience were extracted from dimensions including spatial layout, functional experience, and decorative atmosphere, resulting in an 11-item spatial environmental perception scale (He et al., 2026).

The second-stage evaluation was completed by the same 30 valid participants who had participated in the first-stage experiment and was conducted only for the 45 representative images. Each of the three space types contained 15 images, with low-, medium-, and high-homeliness images presented in a randomized order. Short breaks were provided after approximately every five images to reduce fatigue and repetitive response patterns caused by continuous rating. For each image, the mean rating across the 30 participants was calculated and subsequently used for integrated analyses with the homeliness scores and eye-tracking metrics.

2.6.3 Reliability and validity tests

Internal consistency was assessed using Cronbach’s α . KMO and Bartlett’s test were used to assess sampling adequacy and whether the correlation structure was suitable for factor analysis (Table 4).

Table 4
Reliability and validity tests

Data types	Check	Spatial type	Cronbach’s α	KMO	Bartlett
“Homeliness” Questionnaire Data	Assessing the stability, reliability, and validity of subjective responses from older adults	Resident spaces	0.945	0.832	≈ 0.000
		Communal activity spaces	0.936	0.912	≈ 0.000
		Circulation spaces	0.924	0.851	≈ 0.000
Environmental perception questionnaire data		Resident spaces	0.921	0.852	≈ 0.000
		Communal activity spaces	0.917	0.892	≈ 0.000
		Circulation spaces	0.927	0.836	≈ 0.000

2.7 Data analysis

Because the primary research questions concerned differences among environmental scenes rather than inter-individual differences, participant-level responses were aggregated to derive image-level measures. The subsequent analyses should therefore be interpreted as scene-level exploratory analyses rather than individual-level causal inference. All statistical analyses were performed in Python. First, the mean, standard deviation, minimum, and maximum values were calculated for homeliness scores and image-level overall TFD, FC, and RC in each group. Because each homeliness group within each space type contained only five images, and the AOI-based metrics included a considerable number of zero values and showed skewed distributions, the Kruskal–Wallis H test was used to compare differences among the high-, medium-, and low-homeliness groups. Next, using the 15 representative images within each space type as the analytical sample, Spearman rank correlations were calculated between the TFD, FC, and RC of individual AOI elements and continuous homeliness scores. Only elements appearing in at least five images were included. To account for multiple comparisons, the Benjamini–Hochberg procedure was applied separately to each eye-tracking metric within each space type for false discovery rate (FDR) correction. A two-sided $p < 0.05$ was considered statistically significant before correction, while $q < 0.05$ was considered robustly significant after FDR correction. Values of $0.05 \leq p < 0.10$ were treated as exploratory trends.

For the spatial environmental perception questionnaire administered in the second stage, the 15 representative images within each space type were used as the units of analysis. Spearman correlations were calculated between the 11 environmental items and continuous homeliness scores, with Benjamini–Hochberg FDR correction performed separately within each space type. Mean scores for each item in the low-, medium-, and high-homeliness groups were also reported to describe the gradient of environmental evaluations from low to high homeliness. Because the spatial environmental perception questionnaire was administered only for the 45 selected representative images and was completed by the same participants who completed the homeliness questionnaire, these correlation analyses were primarily used for supplementary interpretation and evidence triangulation rather than as independent causal validation.

Finally, the original spatial images, AOI-based eye-tracking metrics, heatmaps, scanpath plots, and questionnaire results were interpreted jointly. The interpretation followed the principle that visual attention does not directly indicate preference. Eye-tracking metrics were first used to determine which spatial elements attracted or occupied visual attention; the spatial environmental perception questionnaire was then used to identify how these environmental attributes were subjectively evaluated; and the homeliness questionnaire reflected the overall emotional response to each scene. A spatial element was identified as a potential positive or negative cue of homeliness only when the eye-tracking results, environmental evaluations, element composition, locations of fixation hotspots, scanpath sequences, and direction of homeliness scores provided mutually consistent evidence.

3. Results

3.1 Distribution and grouping of homeliness scores

Clear low-medium-high gradients in homeliness scores were observed within all three space types (Figs. 4 and 5). The differences in homeliness scores among the three groups were statistically significant within each space type (Kruskal–Wallis $H = 12.500$, $p = 0.002$), indicating that the selected representative images formed distinct levels of homeliness.

3.2 Between-group differences in overall eye-tracking metrics

In residential spaces, overall TFD was highest in the low-homeliness group but did not show a monotonic change with increasing homeliness. In contrast, overall FC and RC gradually increased from the low- to the high-homeliness group. In communal activity spaces, overall TFD increased from 4.627 to 7.341 and overall FC from 8.398 to 12.428. Similarly, in circulation spaces, overall TFD increased from 2.355 to 4.976 and overall FC from 4.364 to 8.630, showing descriptive increasing trends with higher levels of homeliness (Fig. 6). However, the Kruskal–Wallis tests showed that between-group differences were not statistically significant at $p < 0.05$ for any of the three space types, although communal TFD approached significance ($p = 0.067$) (Table 5).

However, overall eye-tracking metrics may obscure the redistribution of attention among different spatial elements. Therefore, the subsequent analyses further examined differences in the objects of visual attention and their spatial distribution across different levels of homeliness, focusing on broad AOI categories, specific spatial elements, heatmaps, and scanpath patterns.

Table 5
Kruskal–Wallis tests for overall eye-tracking metrics

Spatial type	Indicator	H	p
Residential spaces	TFD	0.260	0.878
Residential spaces	FC	1.623	0.444
Residential spaces	RC	0.947	0.623
Communal activity spaces	TFD	5.42	0.067
Communal activity spaces	FC	4.46	0.108
Communal activity spaces	RC	4.5	0.105
Circulation spaces	TFD	3.62	0.164
Circulation spaces	FC	2.96	0.228
Circulation spaces	RC	3.86	0.145

3.3 Differences in visual attention at the level of major element categories

Comparisons among the three homeliness groups at the level of major element categories yielded the following results (Fig. 7 and Table 6):

(I) Residential spaces. TFD for Category A decreased from 4.142 in the low-homeliness group to 1.920 in the high-homeliness group. In contrast, TFD for Category B, Category D, and Category F increased with higher levels of homeliness. Category E attracted noticeable attention only in the low-homeliness group, with significant between-group differences in both TFD and FC ($H = 6.898$, $p = 0.032$).

(II) Communal activity spaces. TFD, FC, and RC for Category A all increased markedly from the low- to the high-homeliness group, with TFD reaching 3.196 in the high-homeliness group. This between-group difference was statistically significant ($H = 6.305$, $p = 0.043$). This suggests that wooden furniture, sofas, and personalised belongings played a more prominent visual role in communal activity spaces with high homeliness. TFD and FC for Category B were also substantially higher in the high-homeliness group than in the low- and medium-homeliness groups. In contrast, the mean values for Category D decreased in the high-homeliness group.

(III) Circulation spaces. Category A, Category B, and Category C generally showed higher eye-tracking values in the high-homeliness group than in the low-homeliness group. In particular, TFD for Category A increased from 0.698 to 2.038, while FC increased from 1.154 to 3.176. Category F showed higher values in the low-homeliness group, possibly because signage, door frames, reception desks, or the ends of narrow corridors became highly salient visual targets. However, none of the between-group differences for the major AOI categories reached statistical significance.

Table 6
Between-group comparisons and statistical significance of key element categories across the three space types

Spacial	Element	Indicator	Low/medium/high	H	p
RS	A	TFD	4.142/2.208/1.92	4.94	0.085
RS	D	TFD	0.154 / 0.736 / 1.060	5.391	0.068
RS	E	TFD	0.571 / 0 / 0	6.898	0.032
RS	E	FC	1.018 / 0 / 0	6.898	0.032
RS	F	TFD	0.082 / 0.520 / 0.700	5.227	0.073
CAS	A	TFD	0.814 / 1.737 / 3.196	6.305	0.043
CAS	A	FC	1.486 / 3.194 / 5.710	5.217	0.074
CAS	D	TFD	1.634 / 2.647 / 0.670	5.18	0.075
CAS	D	FC	3.224 / 5.236 / 1.160	5.360	0.069
CS	A/B/C	TFD/FC/RC	the values were higher in the high-homeliness group.	—	> 0.10

3.4 Correlations between specific spatial elements and homeliness scores

Figure 8 presents the Spearman correlation results between frequently occurring spatial elements and homeliness scores across the three space types. After false discovery rate (FDR) correction, two associations remained significant at $q < 0.05$: TFD for greenery in communal activity spaces ($\rho = 0.756$, $p = 0.001$, $q = 0.031$) and FC for greenery in communal activity spaces ($\rho = 0.746$, $p = 0.001$, $q = 0.031$). Several other associations with $p < 0.05$ or $p < 0.10$ should be interpreted as exploratory evidence.

In residential spaces, window views were positively correlated with homeliness scores across TFD, FC, and RC, with the strongest association observed for RC ($\rho = 0.740$, $p = 0.002$; FC: $\rho = 0.536$, $p = 0.039$; TFD: $\rho = 0.491$, $p = 0.063$), although this association did not survive FDR correction ($q = 0.078$). This indicates that window views in rooms with higher homeliness were not only noticed but were also more likely to attract repeated visual attention. TFD, FC, and RC for table-and-chair arrangements were also positively correlated with homeliness scores ($\rho = 0.595$, $p = 0.019$; $\rho = 0.516$, $p = 0.049$; $\rho = 0.543$, $p = 0.036$, respectively). In contrast, TFD and FC for beds showed negative trends ($\rho = -0.504$, $p = 0.056$; $\rho = -0.446$, $p = 0.095$), and sofa RC showed a positive trend ($\rho = 0.468$, $p = 0.079$).

In communal activity spaces, greenery showed the strongest positive correlations with homeliness across all three eye-tracking metrics (TFD: $\rho = 0.756$, $p = 0.001$; FC: $\rho = 0.746$, $p = 0.001$; RC: $\rho = 0.561$, $p = 0.030$), with TFD and FC surviving FDR correction. Positive associations were also observed for sofas across all three metrics (TFD: $\rho = 0.651$, $p = 0.009$; FC: $\rho = 0.662$, $p = 0.007$; RC: $\rho = 0.640$, $p = 0.010$) and for wooden furniture TFD and FC ($\rho = 0.609$, $p = 0.016$; $\rho = 0.524$, $p = 0.045$), suggesting that domestic seating and wooden finishes played a prominent visual role in high-homeliness communal spaces. In contrast, TFD and FC for table-and-chair arrangements showed negative trends ($\rho = -0.446$, $p = 0.095$; $\rho = -0.468$, $p = 0.079$).

In circulation spaces, greenery showed robust positive correlations across all three eye-tracking metrics (TFD: $\rho = 0.685$, $p = 0.005$; FC: $\rho = 0.689$, $p = 0.005$; RC: $\rho = 0.754$, $p = 0.001$), with RC being the strongest. Although these associations did not survive FDR correction at $q < 0.05$ (smallest $q = 0.059$), their directions were highly consistent across all three metrics and were supported by visual evidence of greenery and pause areas in high-homeliness corridor images. RC for decorative objects also showed a positive trend ($\rho = 0.457$, $p = 0.087$).

3.5 Correlations between spatial environmental perception attributes and homeliness scores

The spatial environmental perception questionnaire showed that differences in homeliness across the three space types were associated not only with changes in the objects receiving visual attention, but also with systematic differences in evaluations of spatial function, furniture quality, colours and materials, connections with nature, and overall visual coherence. Because the spatial environmental

perception questionnaire and the homeliness questionnaire were completed by the same participants, the following results are used to characterize the environmental perceptual basis underlying different homeliness scores rather than as independent evidence of causality. Table 7 presents the key items with relatively strong statistical associations and interpretive consistency with the eye-tracking results.

In residential spaces, furniture design ($\rho = 0.929$, $q < 0.001$), spatial function ($\rho = 0.909$, $q < 0.001$), furniture style ($\rho = 0.903$, $q < 0.001$), and diversity of functional areas ($\rho = 0.895$, $q < 0.001$) showed the strongest associations with homeliness. The corresponding mean scores for the low-, medium-, and high-homeliness groups increased progressively from 2.27/2.95/3.42, 2.14/2.75/3.36, 1.92/2.82/3.36, and 1.89/2.66/3.28, respectively. Views of greenery were also positively associated with homeliness ($\rho = 0.602$, $q = 0.030$).

In communal activity spaces, diversity of functional areas ($\rho = 0.823$, $q = 0.003$), furniture style ($\rho = 0.809$, $q = 0.003$), furniture design ($\rho = 0.803$, $q = 0.003$), and overall visual coherence and aesthetics ($\rho = 0.710$, $q = 0.009$) were significantly and positively correlated with homeliness. Views of greenery also showed a positive association ($\rho = 0.623$, $q = 0.022$). In contrast, the amount of furniture was not significantly associated with homeliness ($\rho = 0.248$, $p = 0.372$), nor were ratings of social areas ($\rho = 0.023$, $p = 0.934$).

In circulation spaces, furniture placement ($\rho = 0.889$, $q < 0.001$), richness of colour variety ($\rho = 0.872$, $q < 0.001$), spatial function ($\rho = 0.861$, $q < 0.001$), overall visual coherence and aesthetics ($\rho = 0.859$, $q < 0.001$), and views of greenery ($\rho = 0.767$, $q = 0.003$) showed relatively strong associations with homeliness. Mean ratings for views of greenery increased from 1.53 in the low-homeliness group to 2.04 in the medium-homeliness group and 2.83 in the high-homeliness group, while ratings for furniture placement increased from 2.70 to 2.94 and 3.49, respectively.

Table 7
Correlations between spatial environmental perception attributes and homeliness scores

Spacial	Environmental attribute	Mean (Low/medium/high)	ρ	p	FDR q	Integrated interpretation
Residential spaces	Furniture design	2.27/2.95/3.42	0.929	< 0.001	< 0.001	Furniture quality and sense of everyday living
	Spatial function	2.14/2.75/3.36	0.909	< 0.001	< 0.001	Functional completeness
	Furniture style	1.92/2.82/3.36	0.903	< 0.001	< 0.001	Non-institutional style
	Diversity of functional areas	1.89/2.66/3.28	0.895	< 0.001	< 0.001	Support for diverse daily activities
	Extent of greenery view	1.55/1.99/2.47	0.602	0.018	0.030	Connection with nature
Communal activity spaces	Diversity of functional areas	2.45/2.92/3.01	0.823	< 0.001	0.003	Activity choice and multifunctional use
	Furniture style	2.36/3.04/3.17	0.809	< 0.001	0.003	Domestic rather than standardised character
	Furniture design	2.63/3.09/3.24	0.803	< 0.001	0.003	Comfort and usability
	Overall visual coherence and aesthetics	2.64/3.17/3.43	0.710	0.003	0.009	Overall spatial coherence
	Extent of greenery view	2.23/2.41/2.89	0.623	0.013	0.022	Natural cues
Circulation spaces	Furniture placement	2.70/2.94/3.49	0.889	< 0.001	< 0.001	Organisation of nodes along the route
	Richness of colour variety	2.39/2.68/3.14	0.872	< 0.001	< 0.001	Reduction of visual monotony
	Spatial function	2.78/2.96/3.52	0.861	< 0.001	< 0.001	Integration of movement, pausing, and orientation

Spatial	Environmental attribute	Mean (Low/medium/high)	ρ	p	FDR q	Integrated interpretation
	Overall visual coherence and aesthetics	2.61/3.05/3.53	0.859	< 0.001	< 0.001	Coordination between interfaces and spatial nodes
	Extent of greenery view	1.53/2.04/2.83	0.767	< 0.001	0.003	Natural and destination cues

4. Discussion

4.1 Visual attention and homeliness: from attention intensity to environmental meaning

No significant differences were found in overall eye-tracking metrics among homeliness groups across the three space types. Thus, older adults' overall visual attention did not consistently increase with higher homeliness. Homeliness is not simply “looking longer” or “looking more”; it depends more on which spatial contents receive limited attention and what environmental meanings are attributed to them. TFD, FC, and RC indicate visual attention but cannot determine whether it is driven by positive attraction or by visual incongruity, functional recognition, or interpretative demand. Beds and care facilities in low-homeliness residential spaces, standardized tables and chairs in communal spaces, and signage and corridor ends in low-homeliness circulation spaces may all form visual hotspots without receiving higher homeliness evaluations. Visual salience is a prerequisite for perception but not equivalent to positive affect; eye-tracking metrics have no stable one-to-one correspondence with subjective preference (Aalto and Steinert, 2025; Chen et al., 2023).

This study therefore supports an interpretive pathway of “visual capture–environmental appraisal–affective integration” (Fig. 9). Spatial elements enter visual attention through scale, position, colour contrast, and functional characteristics. Older adults then evaluate these elements and the resulting environment in terms of familiarity, comfort, functionality, safety, and friendliness based on everyday experience. These evaluations are integrated into overall homeliness. This pathway is not a verified causal mediation model but an explanatory framework supported by eye-tracking, environmental perception questionnaires, and image evidence. Eye-tracking answers “where attention is directed,” the questionnaire explains “how attended space is evaluated,” and the homeliness questionnaire reflects “the overall affective outcome.” Combining these three levels avoids equating high gaze with positive preference. This is especially important for elderly care facilities, which combine residential and care functions. Wheelchairs, care fixtures, and institutional signage may be quickly recognised and repeatedly inspected because of their functional importance, while reinforcing perceptions of being managed, cared for, or institutionalised. Homeliness should therefore be interpreted not only by attention quantity but by

the everyday meanings carried by attended objects. This also explains why overall eye-tracking metrics were non-significant while AOI and environmental evaluations still differed clearly.

4.2 Person-environment interactions across different spatial functions

4.2.1 Residential spaces: continuity, autonomy and connection to the outside

Residential spaces are the most private areas in elderly care facilities and provide the strongest continuity with older adults' everyday lives. After FDR correction, the RC of window views showed the strongest positive correlation with homeliness ($p = 0.740$, $p = 0.002$), although it did not survive FDR correction ($q = 0.078$), indicating that window views not only attracted initial attention but also encouraged repeated revisits. Compared with a single prolonged fixation, revisits better reflect sustained visual value, which is consistent with existing research on outdoor connections, window-related experience, and nature views in elderly care environments (Fleming and Kydd, 2018; Verderber et al., 2023). Windows also provide information about weather, time, plant growth, and social activity, maintaining the connection between residents' personal lives and the outside world, weakening institutional boundaries, and enhancing the space's openness and sense of continuity.

The TFD, FC, and RC of tables and chairs showed positive associations with homeliness, while the TFD and FC of beds showed negative trends. Although these correlations did not remain robust after FDR correction, they are consistent with evidence from questionnaires and image analyses. Furniture design, spatial function, furniture style, and diversity of functional areas correlate most strongly with homeliness ($\rho \approx 0.90$). Homeliness depends less on furniture quantity than on whether the space supports a complete structure for daily life. The bed itself does not reduce homeliness, but when it dominates the visual center alongside wheelchairs and standardized bedside cabinets, the room's meaning compresses into a "sleep and care" space. High-homeliness rooms typically combine tables and chairs, sofas, window views, greenery, storage, and personal items to support reading, viewing scenery, receiving visitors, and self-directed activities (Blackler et al., 2023). Homeliness is thus not simply "domestic-style decoration" (Chen et al., 2023) but whether older adults can continue their everyday life. Its core mechanism is "continuity of personal life and autonomous control" (Van Steenwinkel et al., 2017; Sun et al., 2025): high-homeliness environments do not remove care functions but prevent them from dominating the visual field.

4.2.2 Communal activity spaces: choice and shared everyday life

Findings from the analysis of communal activity spaces show that homeliness cannot be explained simply by the quantity of furniture or the number of social facilities. After FDR correction, the TFD and FC of greenery showed a robust positive correlation with homeliness, which was one of the most stable

positive AOI correlations across the three space types; the TFD of wooden furniture, as well as the TFD, FC and RC of sofas, also showed positive trends. Natural elements and domestic-style furniture are more likely to receive positive visual attention when they contribute to forming everyday shared living environments. In contrast, several eye-tracking metrics for tables and chairs showed negative trends. In low- and medium-homeliness scenes, tables and chairs are often numerous, uniform in style, arranged in rows, or concentrated in the center of the space. They create strong visual salience while reinforcing the characteristics of collective dining, standardized activities, and institutional management. By contrast, high-homeliness scenes usually combine sofas, side tables, round tables, dining tables, individual chairs, and display cabinets to form multiple activity nodes with different scales and functions.

The environmental questionnaire showed that the diversity of functional areas, furniture style, furniture design, and visual coherence and aesthetics were significantly positively correlated with homeliness, while furniture quantity and social area ratings had no significant correlation. The core issue is not whether tables, chairs, or social areas exist, but whether the facilities can support diverse activities and behavioral choices in shared spaces. The value of communal spaces depends not only on area or furniture capacity but also on spatial configuration, activity affordances, and opportunities for spontaneous social interaction (Nordin et al., 2017; Jang, 2023; Chaudhury and Xu, 2022). Homeliness in communal spaces is closer to "chosen shared living" than to complete collective facilities. Home living rooms feel lived-in not because they have more furniture but because the same space accommodates solitude, conversation, small-group interaction, dining, and reading. Reliance on standardized tables and chairs may support collective activities while restricting individual choice. Its core mechanism is "social affordance, activity choice, and multiple scales of intimacy."

4.2.3 Circulation spaces: legibility, mobility support and environmental security

Compared with residential spaces and communal activity spaces, neither the major AOI categories nor the specific elements in circulation spaces showed robust significant associations after FDR correction, so these results should be interpreted with caution. Even so, the TFD, FC and RC of greenery were positively correlated with homeliness, and the three eye-tracking metrics showed relatively consistent correlation directions. Circulation scenes with high homeliness also share common visual features such as wooden finishes, greenery, artwork, natural light, and resting furniture. Results from the environmental questionnaire support this pattern: furniture placement, color richness, spatial function, visual coherence and aesthetics, and greenery views were all strongly positively associated with homeliness, with a correlation coefficient of $p = 0.889$ for furniture placement, 0.872 for color richness, 0.861 for spatial function, and 0.859 for coherence and aesthetics. In circulation spaces, the location and organization of an element along the path may matter more than the element itself (Merhav and Fisher-Gewirtzman, 2023).

Conventional corridors in elderly care facilities are primarily designed to meet circulation, nursing, and fire safety requirements. Continuous doorways, handrails, signage, and long linear perspectives create a

legible yet strongly transitional space. In low-homeliness corridors, visual hotspots concentrate on corridor ends, reception desks, door frames, or wheelchairs, supporting directional recognition but framing the space around movement and management with few stopping points. In contrast, high-homeliness corridors use greenery, seating, window views, artwork, natural light, and local furniture to break the linear axis into identifiable nodes (Wang and Lu, 2022). For older adults with declining mobility, seating supports physical recovery, window views and greenery provide orientation references, and focal views help establish spatial memory. Circulation quality thus concerns not only movement efficiency but also independent mobility, perceived safety, and legibility (Alam and Kim, 2023; Shabha et al., 2022). The non-significant relationship between barrier-free facilities and homeliness is instructive: handrails are not inherently institutional; their affective meaning depends on materials and integration with the surroundings. What should be avoided is not age-friendly provision, but safety facilities becoming visually dominant in highly medicalized forms.

4.3 A cross-spatial mechanism: from physical elements to environmental meaning

Taken together, the three space types suggest that there is no fixed combination of spatial elements that can universally create homeliness across all interior spaces of elderly care facilities. The role of the same element varies according to its functional context and the types of activities it can support. Residential spaces emphasize continuity of personal life and autonomous arrangement, communal activity spaces emphasize choice and social interaction within shared daily life, while circulation spaces place greater emphasis on orientation, safety, and opportunities to pause during movement. Homeliness in elderly care facilities should therefore be understood in terms of whether a space supports authentic everyday life that is consistent with its functional role.

Another common pattern emerged across all three space types. In high-homeliness environments, visual attention tended to be distributed across multiple spatial nodes with clear everyday meanings, whereas low-homeliness environments were more likely to be dominated by a single large-scale piece of furniture, standardised functional facilities, or highly salient spatial interfaces. This does not mean, however, that a greater number of visual nodes necessarily leads to stronger homeliness. The environmental perception questionnaire showed that the amount of furniture itself was not significantly associated with homeliness in communal activity spaces, whereas furniture design, functional diversity, and overall spatial coherence were more important. Thus, what appears to matter is not visual richness alone, but whether the environment provides a coherent network of everyday-life cues that are understandable, usable, and capable of supporting different choices.

Domestication goes far beyond the superficial replication of residential imagery. If design merely mimics domestic settings through formal devices such as wood grain, warm color palettes, and decorative artworks – while the space itself remains constrained to single-function sleeping, regimented collective activities, or mere through-circulation – its lived meaning will likely remain fundamentally institutional. Conversely, when reading desks and chairs are placed beside beds, communal spaces are configured

into interaction zones of varying scales, and restful, identifiable nodes are integrated into corridors, the space exhibits stronger domestic attributes even while it continues to deliver care and fulfill administrative functions.

Accordingly, this study posits that the core of ****homeliness**** in senior care facilities may not lie in how closely the space resembles a typical residence, but in whether it supports the continuity of everyday life. Homeliness, we argue, is not defined solely by visual stylistic resemblance. Rather, it hinges on whether the built environment enables older adults to maintain their familiar daily routines, retain a degree of choice and autonomy, and establish recognizable personal or shared life orders.

4.4 Implications for age-supportive care environments

The above findings suggest that home-like design in elderly care facilities should shift from simply “adding domestic elements” toward “reconstructing everyday living settings.” Because the three space types serve different functions, their design priorities should also differ.

(I) Residential spaces. The primary goal is to prevent the bed and care-related facilities from dominating the visual and functional meaning of the room. While ensuring care safety, design should strengthen visual connections among the bed, seating areas, and window views, while introducing everyday-life nodes that support reading, drinking, receiving visitors, storage, and personal display. This allows older adults to engage in a wider range of daily activities beyond remaining in bed. Wheelchairs, care equipment, and wall-mounted medical fixtures can be visually integrated through built-in solutions, partial concealment, and coordinated materials and colours, thereby reducing their visual dominance and enabling care functions to coexist with the residential identity of the space.

(II) Communal activity spaces. The design focus should shift from maximizing furniture capacity toward providing activity choices at different spatial scales and levels of participation. Large numbers of uniform tables and chairs arranged for a single type of collective activity should be avoided. Instead, sofas, side tables, dining tables, activity tables, and individual chairs can be combined to create settings for individual stays, one-to-one conversations, and small-group activities, thereby supporting different levels of social intimacy. Greenery, window views, display cabinets, artworks, and domestic-style lighting can be incorporated so that furniture, natural elements, and furnishings work together to form clearly identifiable everyday-life settings, rather than functioning as isolated decorative additions.

(III) Circulation spaces. The design priority should extend beyond ensuring efficient movement toward creating continuous, legible, and pause-supportive route experiences. Visual nodes can be introduced along circulation paths through wooden or warm-toned finishes, greenery, artworks, natural light, and localized furniture arrangements. Resting seats and recognizable focal points should also be provided along longer routes. Functional facilities such as handrails and signage should be integrated with wall finishes, colour schemes, and furniture systems. In this way, clear wayfinding and safe use can be maintained while reducing an overly medicalized visual impression.

4.5 Theoretical and methodological implications

This study extends the assessment of homeliness from an overall subjective rating to the level of specific objects of visual attention. The findings demonstrate that similar amounts of overall visual attention may correspond to different spatial meanings, and that visual attention should not be equated with subjective preference. Differences across the three space types further indicate that homeliness is jointly shaped by spatial function and visual cues: residential spaces emphasize continuity of personal life, communal activity spaces emphasize choice within shared everyday life, and circulation spaces emphasize safety, orientation, and opportunities to pause.

Methodologically, this study establishes a multilayer evidence-triangulation framework integrating eye-tracking metrics, affective evaluation, environmental perception assessment, and image-based evidence. Eye-tracking data are used to identify the objects receiving visual attention, the homeliness questionnaire captures the overall affective response, and the environmental perception questionnaire provides supplementary interpretation of how specific spatial attributes are evaluated. Compared with approaches that rely solely on heatmaps, correlation coefficients, or subjective ratings, this framework enables behavioural data, perceptual evaluations, and spatial context to be cross-validated. It therefore allows a more cautious distinction among visual attention driven by positive attraction, negative salience, and the absence of alternative salient elements.

Several seemingly counterintuitive findings in this study further demonstrate the necessity of integrating multiple sources of evidence. For example, beds and standardised table-and-chair arrangements attracted relatively high levels of visual attention but were not associated with higher homeliness. Such findings indicate that eye-tracking results, when interpreted without environmental evaluations and spatial context, can easily lead to the misinterpretation of visual salience as preference. The methodological contribution of this study therefore lies not only in identifying spatial elements associated with homeliness, but also in providing an analytical approach that helps prevent overinterpretation of eye-tracking data.

4.6 Limitations and future research

This study has several limitations. First, static images were used as visual stimuli. Although this approach enabled greater control over visual input, it could not fully reproduce multisensory experiences in real environments, including sound, lighting changes, thermal conditions, bodily movement, and social interaction. Future studies could employ virtual reality or experiments involving movement through real spaces to improve ecological validity.

Second, only 15 representative images were analyzed for each space type, resulting in a limited image-level sample size and consequently limited statistical power. Future studies should further validate the findings using a larger and more diverse set of spatial scenes.

Third, the frequency and area of AOI elements varied across images, while the current eye-tracking metrics were not normalized by AOI area, visual centrality, or element salience. Future research could incorporate AOI-area normalization and additional metrics, such as time to first fixation and mean fixation duration, to better distinguish attention driven by physical salience from attention associated with environmental meaning.

Fourth, the participants in this study were community-dwelling older adults rather than current residents of elderly care facilities. Although this population was able to provide visual and perceptual evaluations of elderly care environments, long-term residential experience, level of care dependency, and familiarity with institutional living may influence perceptions of care facilities, privacy, social interaction, and environmental safety. Future research should therefore recruit older adults currently living in elderly care facilities and compare their visual attention patterns and formation of homeliness with those of community-dwelling older adults.

5. Conclusions

This study integrated homeliness ratings, spatial environmental perception assessments, and eye-tracking data from 30 older adults to examine visual attention and environmental evaluation characteristics across 45 representative images with low, medium, and high levels of homeliness in residential spaces, communal activity spaces, and circulation spaces in elderly care facilities. The main conclusions are as follows:

(I) No significant between-group differences were found in overall TFD, FC, or RC across the three space types. This indicates that homeliness cannot be determined solely by the overall amount of visual attention; what spatial elements receive attention is more important than how much attention is allocated overall.

(II) Homeliness in residential spaces was closely associated with window views, everyday-life activity nodes, and the quality of the furniture environment. The RC for window views showed the strongest positive correlation with homeliness ($p = 0.740$, $p = 0.002$), although it did not survive FDR correction ($q = 0.078$). Table-and-chair arrangements showed consistent positive correlations across all three eye-tracking metrics, whereas beds showed negative trends, while furniture design, spatial function, furniture style, and diversity of functional areas were the environmental attributes most strongly associated with homeliness. In low-homeliness images, beds, wheelchairs, and care-related facilities were more likely to dominate visual attention.

(III) In communal activity spaces, TFD and FC for greenery showed robust positive correlations with homeliness after FDR correction ($p = 0.756$ and 0.746 , respectively, both $p = 0.001$, $q = 0.031$). Sofa and wooden furniture also showed strong positive associations across multiple metrics. At the category level, domestic elements (Category A) showed a significant increase from the low- to the high-homeliness group ($H = 6.305$, $p = 0.043$). Environmental questionnaire results indicated that diversity of functional areas, furniture style, furniture design, and overall visual coherence and aesthetics were

significantly positively correlated with homeliness. Together, these findings suggest that homeliness in communal spaces is achieved not through maximizing seating capacity but through providing natural visual anchors, comfortable domestic seating, and a variety of activity choices.

(8) In circulation spaces, greenery showed robust positive correlations with homeliness across TFD, FC, and RC ($\rho = 0.685, 0.689, \text{ and } 0.754$, respectively), with RC being the strongest. Although these associations did not remain significant after FDR correction (smallest $q = 0.059$), their consistency across all three metrics and the visual evidence of greenery and pause areas in high-homeliness corridor images suggest that natural visual nodes and rest opportunities along the route play an important role. Environmental evaluations indicated that furniture placement, richness of colour variety, spatial function, overall spatial coherence, and views of greenery were key attributes.

(9) Visual attention identified through eye-tracking should not be equated with subjective preference. Integrating AOI-based eye-tracking metrics with subjective homeliness scores, spatial environmental perception assessments, original images, heat maps, and scan path plots is essential for identifying the visual and environmental mechanisms underlying homeliness.

Overall, creating homeliness in elderly care facilities should go beyond the superficial imitation of residential styles. Instead, natural connections, appropriately arranged everyday furniture, functional areas that provide choice, coordinated colours and materials, identifiable nodes along circulation routes, and visually integrated care facilities should be used to support older adults in maintaining their personal lives and developing emotional belonging within institutional environments.

Declarations

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Author contributions

J.H. and J.J. contributed to conceptualisation, methodology, investigation, data analysis, funding acquisition and manuscript preparation. Y.Q. contributed to conceptualisation, supervision and funding acquisition. Y.Z. and K.L. contributed to data collection and visualisation. Y.G. contributed to methodology and manuscript review. D.Z. contributed to supervision and critical revision. All authors reviewed and approved the final manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval

This study was approved by the Ethics Committee of Xi'an Jiaotong University. All research procedures were performed in accordance with relevant institutional guidelines and regulations and with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to participation.

Data availability

The datasets and materials supporting the findings of this study, including anonymised raw and processed data, questionnaires, experimental protocols, are provided as Supplementary Materials accompanying this manuscript.

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Figures

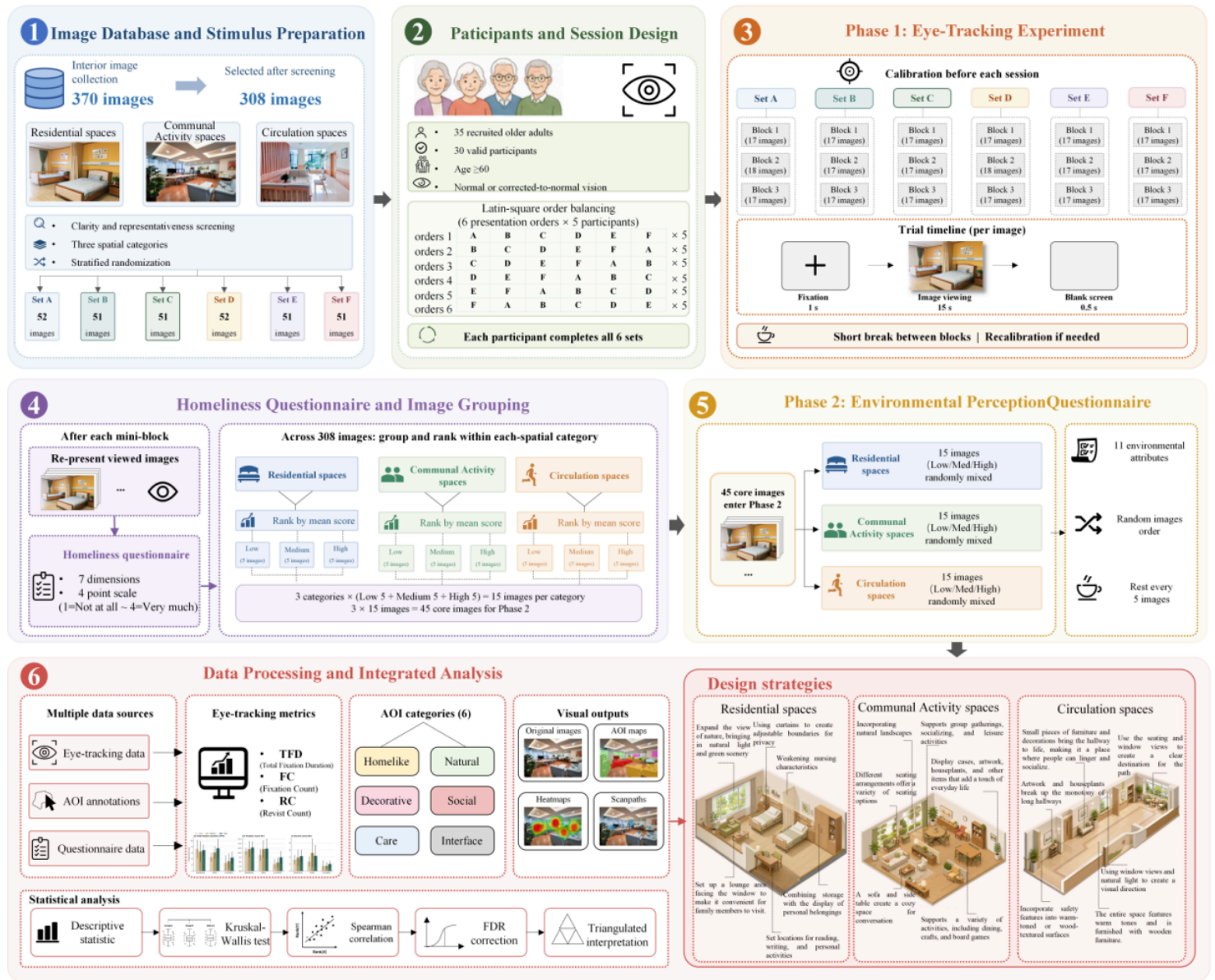


Figure 1

Research framework

Three Types of Spatial Scenario Diagrams Based on “Homeliness” Scores

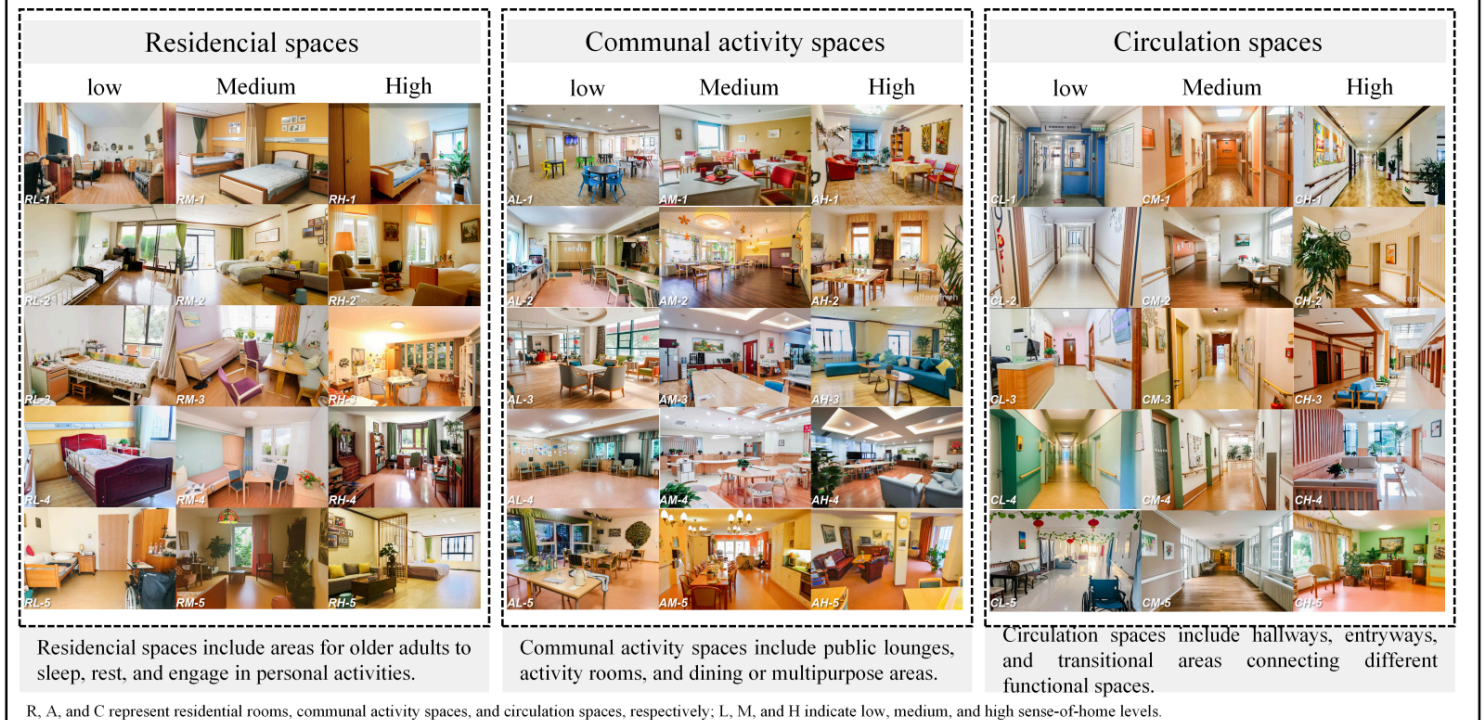


Figure 2

Representative spatial scenes

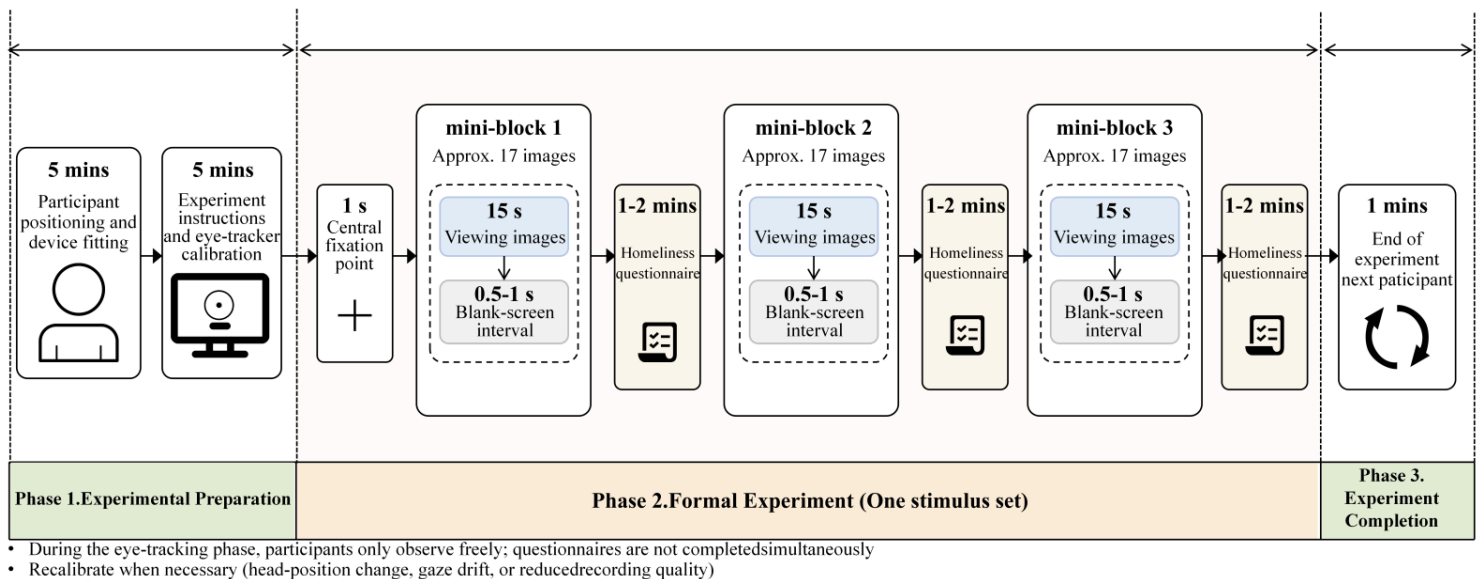


Figure 3

Eye-tracking experimental procedure

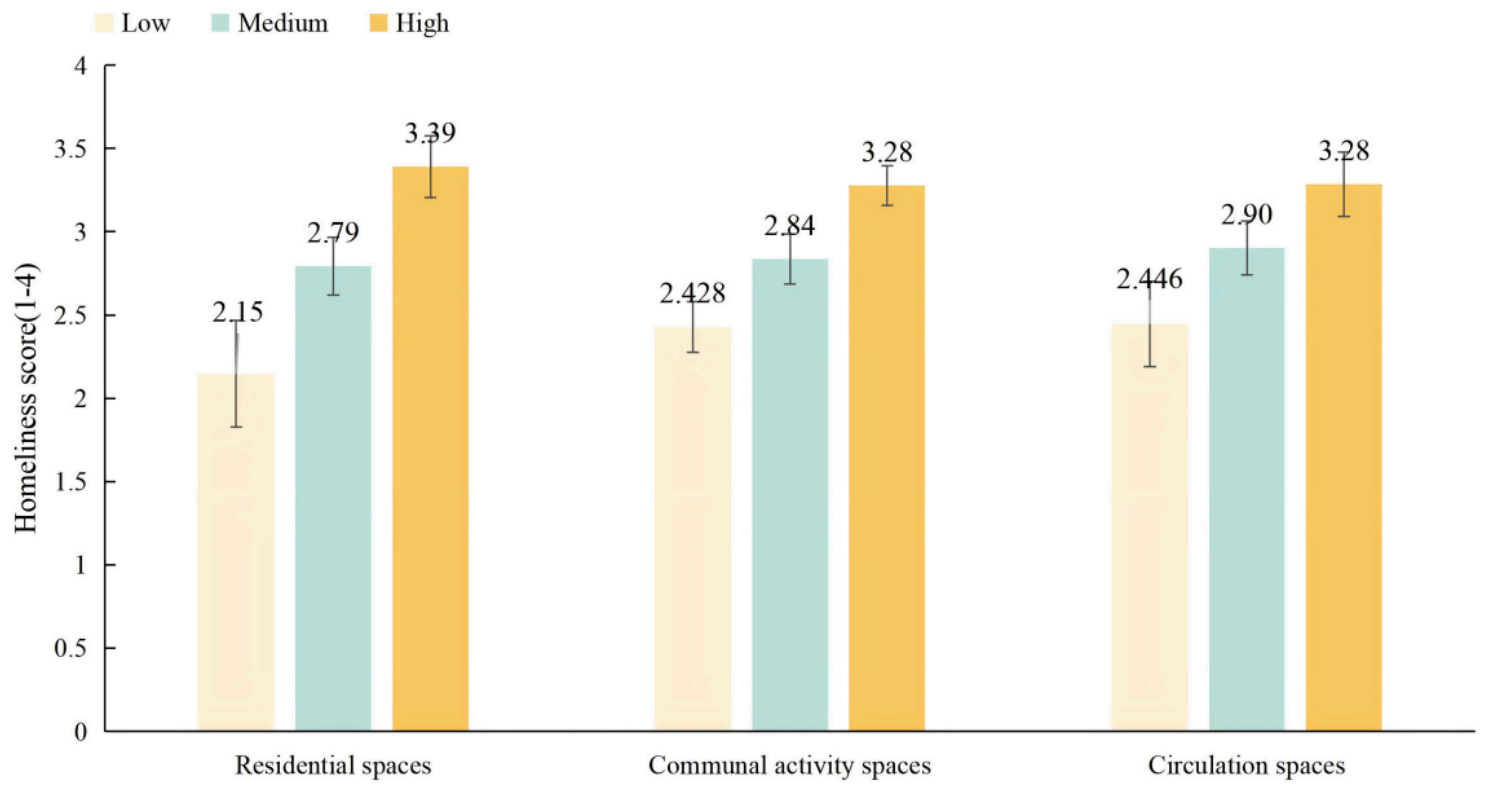


Figure 4

Between-group differences across the three space types

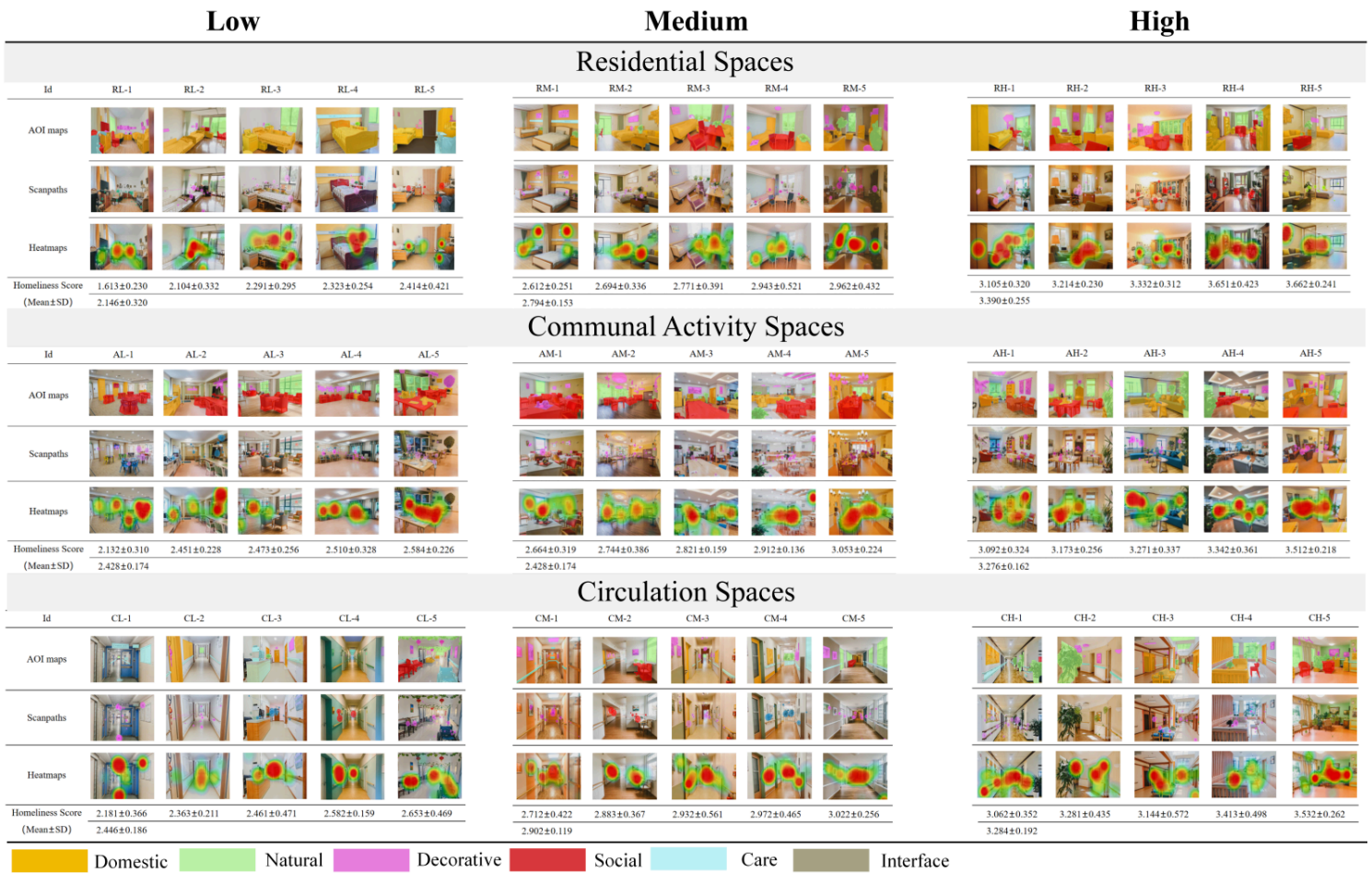


Figure 5

Homeliness scores and corresponding image data for the 45 representative images

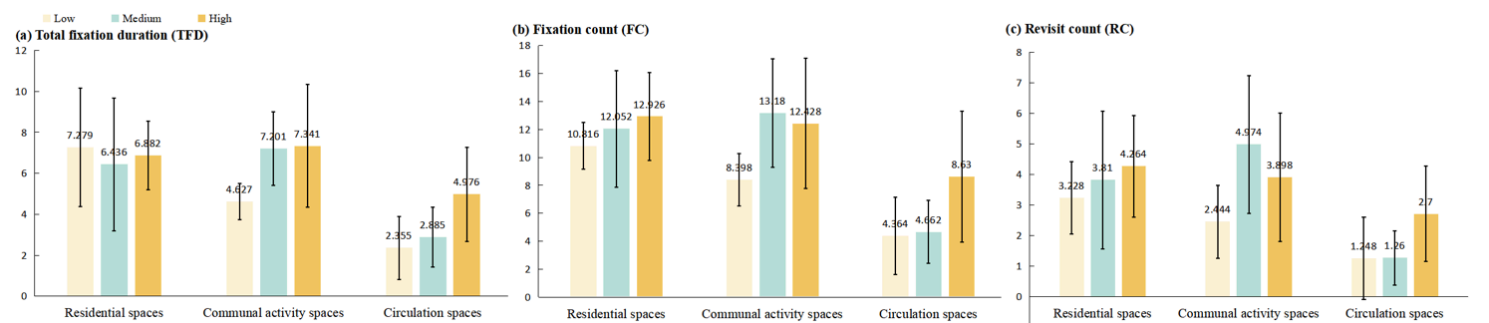


Figure 6

Eye-tracking metrics across different homeliness groups in the three space types

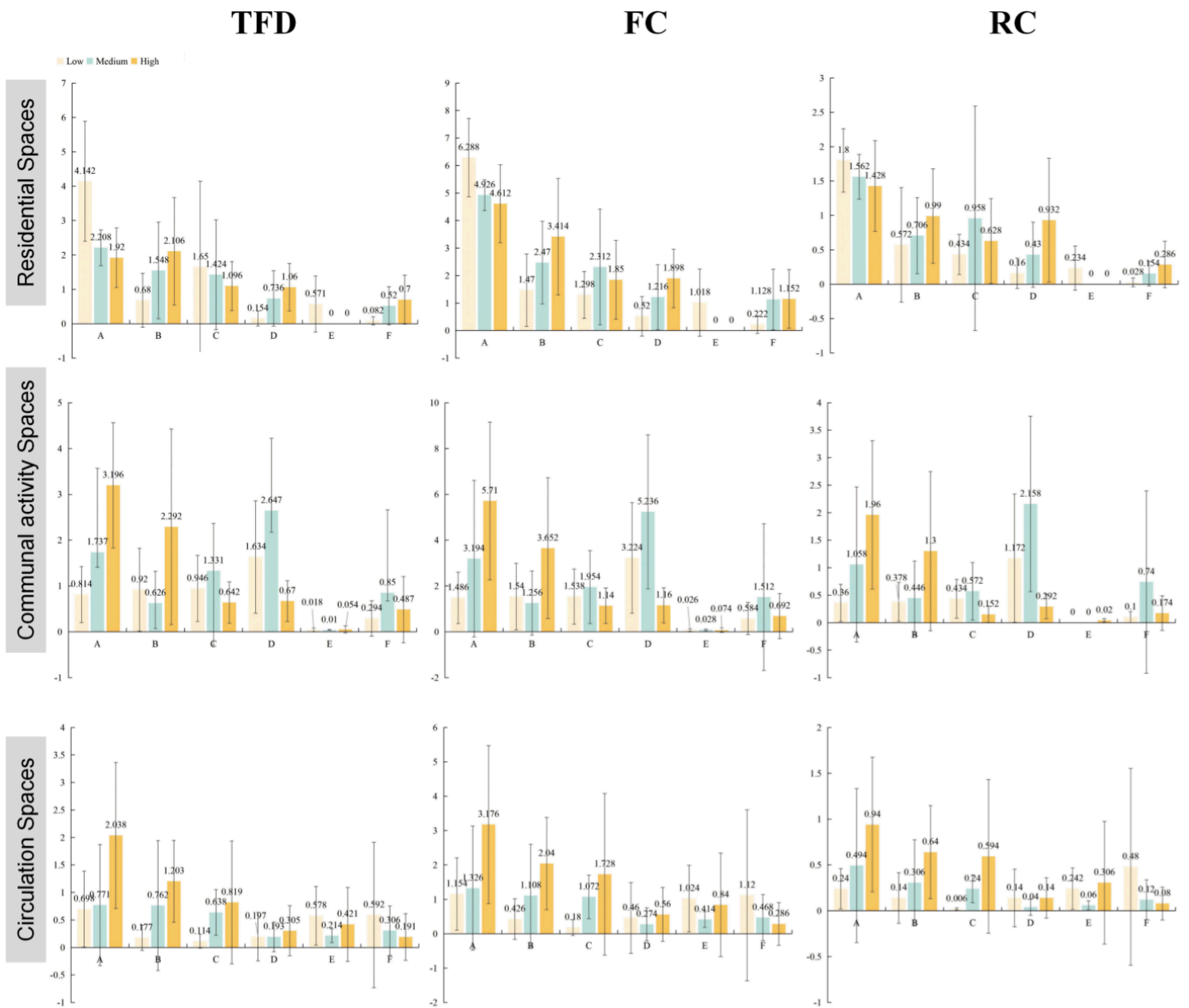


Figure 7

Eye-tracking metrics for major element categories across the three space types

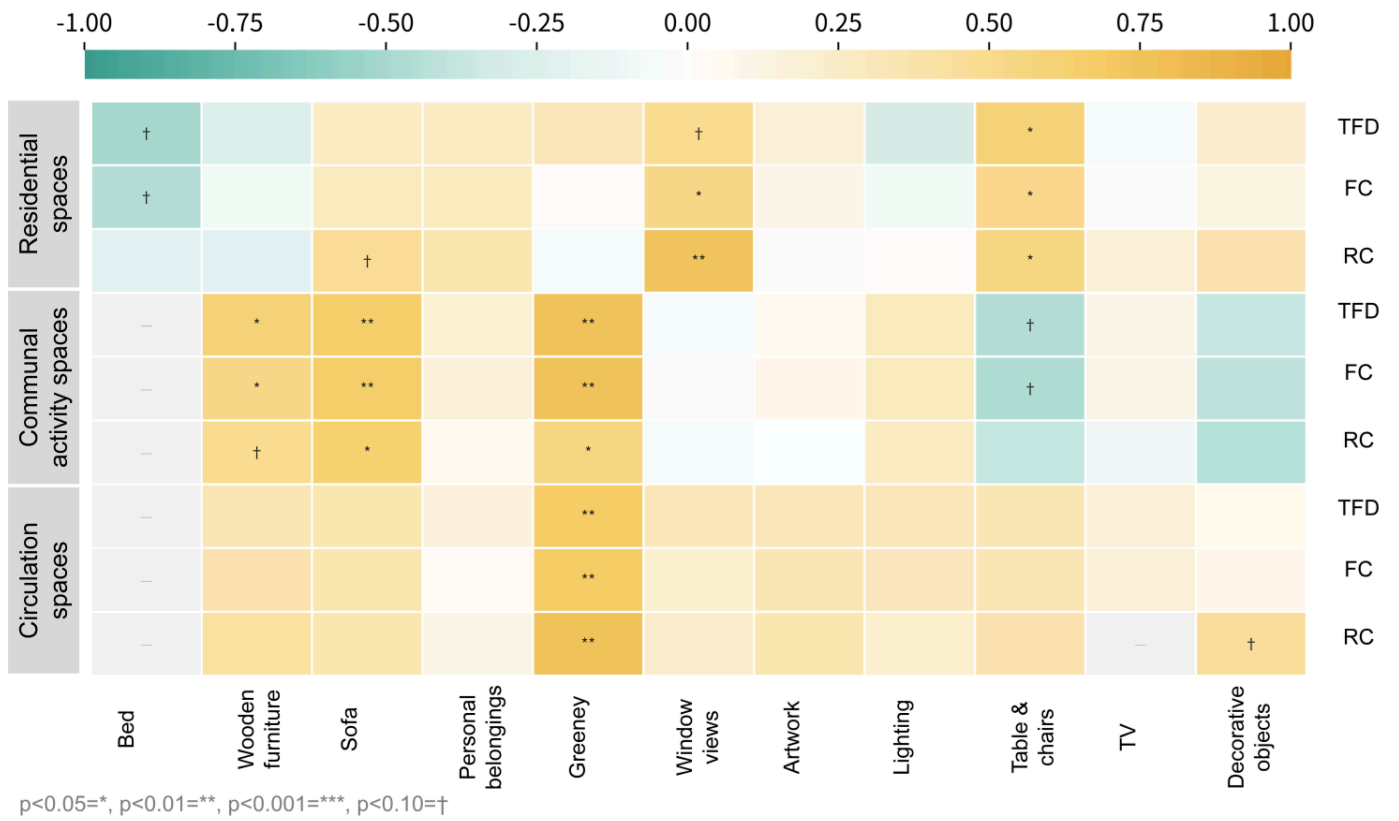


Figure 8

Correlation analysis between eye-tracking metrics of specific spatial elements and homeliness scores

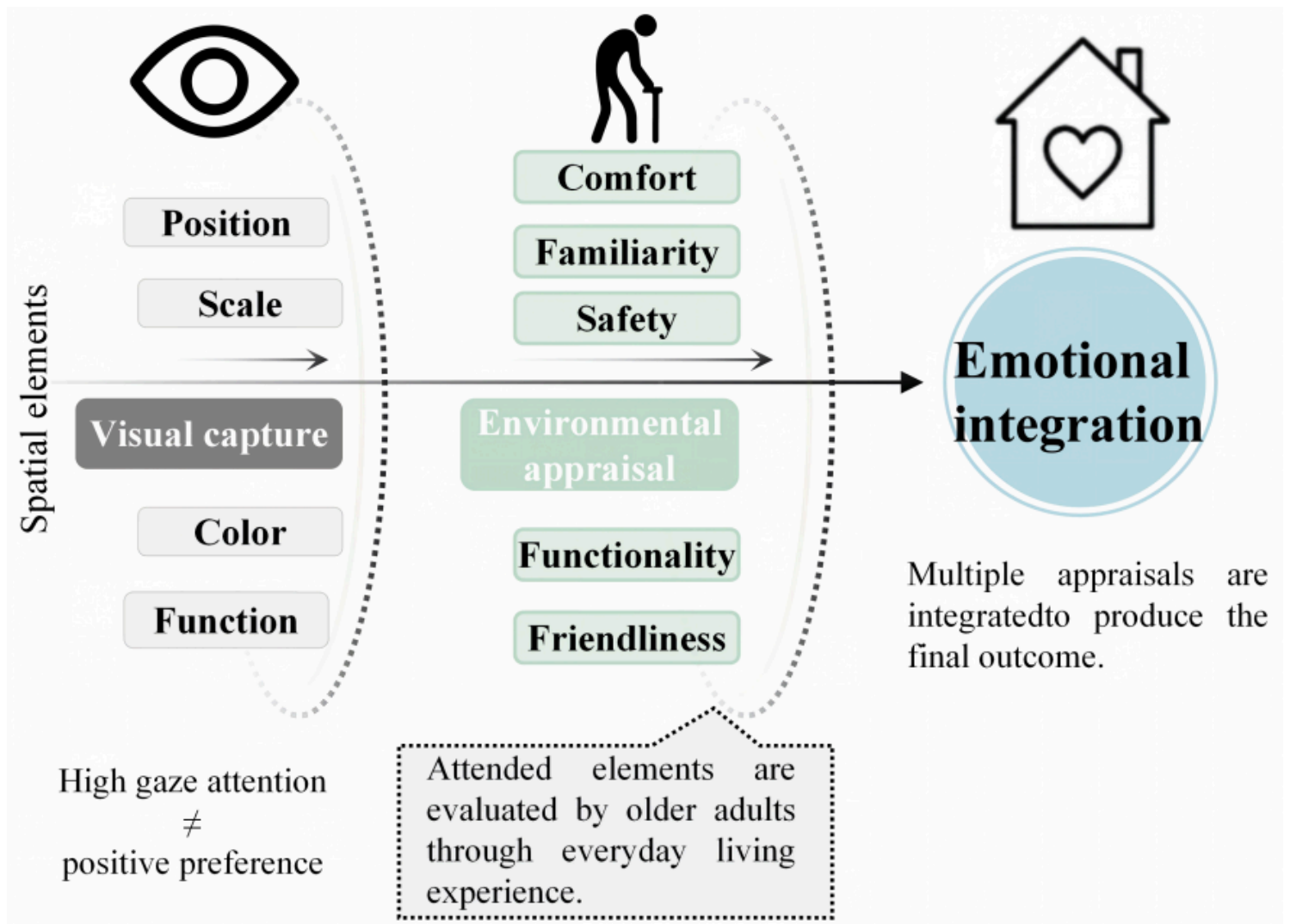


Figure 9

Interpretive pathway from visual attention to homeliness