

## Article

# Relationship between Visual Attention Patterns and Subjective Evaluations in Housing Sales Information: A Study Using Eye-Tracking Technology

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**Abstract:** Traditionally, studies analyzing consumer preferences in real estate have focused on measuring subjective user responses, neglecting associated physiological responses. This study investigates the relationship between visual attention patterns and subjective evaluations of home sales information. Eye-tracking technology was used to record two characteristics of 21 participants' visual behavior while viewing stimuli containing information about home sales (First Fixation Time and Total Fixation Duration). Additionally, participants evaluated their level of satisfaction with nine dwelling characteristics based on a questionnaire adapted for this research (1, quality and finishes of the dwelling; 2, size of the dwelling; 3, dwelling floor level; 4, bright and outdoor orientation of the dwelling; 5, flexible layout; 6, peaceful atmosphere; 7, smart and secure character; 8, privacy; and 9, original and luxurious character). The results demonstrated significant correlations between fixation time on specific areas of the stimulus and subjective ratings of features such as size, quality, finishes, layout, and orientation of the homes. Furthermore, differences based on gender and participants' architecture experience level were observed in visual behavior during image observation. These findings underscore the importance of visual design and presentation in home marketing, as visual attention can influence perceptions of home characteristics and, ultimately, purchase decisions.

**Keywords:** subjective evaluation; physiological measurement; eye tracking; gender; expertise level; housing



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## 1. Introduction

The use of the Internet for preliminary home searches is becoming increasingly common [1]. This channel has evolved into a medium that offers consumers the ability to make initial selections among available homes in the market based on specific features such as quality, size, or floor plans. This trend is also observed in other markets such as fashion [2,3], travel [4,5], and furniture [6]. Consumer intuition and perception play a significant role in this process; however, this evaluation process remains underexplored in the realm of real estate [1].

To date, studies analyzing consumer preferences in real estate have primarily relied on measuring subjective user responses. Preferences regarding design [7], floor plans [8], pricing [9], and interior features [10] have been investigated based on verbal responses from participants. Nevertheless, studies relying solely on verbal responses are subject to limitations due to potential social desirability biases [11], where participants may be inclined to provide socially acceptable or stereotypical responses [12]. Therefore, to truly understand consumer behavior during the selection process, verbal declarations alone are insufficient. Additionally, it is estimated that 95% of thoughts, emotions, and learning occur at the unconscious level [13], emphasizing the need to move beyond subjective

measures [14]. Since the 1990s, emotion studies have stressed the importance of integrating physiological processes with subjective measures [15], arguing that removing physiological criteria from the definition of emotion would strip the concept of one of its core characteristics [16]. Accordingly, the recent study by Janowski et al. proposes the EMOTIF system as an objective measure of the average emotions evoked by the observed stimuli [17]. This approach surpasses classical data analysis methods that do not consider the synergies of the stimulus characteristics themselves on the emotional impact of the user. By integrating these synergies, the EMOTIF system offers a more holistic and accurate understanding of emotional responses.

In this context, some studies introduce physiological measures as an unbiased and sensitive gauge of an individual's reaction to stimuli. Autonomous reactions are difficult to control, making it challenging to conceal true responses [18]. Techniques like functional magnetic resonance imaging [19], eye tracking [1,20], or galvanic skin response [21] measure the observer's unconscious reaction to architectural stimuli. These approaches acknowledge the influence of social-cognitive [22] and physiological factors [23] on perceptual-emotional states, providing objective data that complement subjective cognitive responses [24].

Among physiological response techniques, eye tracking emerges as a reliable method for obtaining objective consumer measures. The eye is the primary element receiving visual information, serving as the sole means for the brain to access external images [25]. Eye tracking technology analyzes gaze behavior, establishing visual patterns based on ocular movements that shift fixation from one area to another within the effective visual field of the fovea [26]. While eye tracking captures various fixation movements, most studies focus on saccadic movements—rapid shifts between fixation points [27,28]. These visual patterns, analyzed in terms of ocular fixations [28], provide insights into visual attention allocated to stimuli [29]. Marketing studies establish a relationship between fixation patterns and increased interest or processing effort during observation [30–32]. This forms the basis for the first hypothesis of this study: (I) There is a relationship between subjects' visual patterns and their evaluation of real estate properties.

Beyond these fixation patterns, individual characteristics are also of interest. Gender differences in visual attention during online shopping have been identified, with women inspecting images more quickly than men [33,34]. Based on these findings, the second hypothesis addresses the (II) significant differences in visual patterns based on participants' gender.

Furthermore, expertise within the real estate sector can lead to discrepancies between clients and architects [35,36]. This necessitates considering both perspectives in space perception and design. The interpretation of plans [36] and architectural text readings can vary based on observer experience [37], whether they are artists [38] or not, and their expertise level [39–42]. Notably, experts tend to avoid re-examining previously viewed areas [37,40]. Stofer and Che [42] also found significant differences in visual patterns between experts and novices, suggesting that stimulus structuring and learning assist novices in developing better visual strategies. Consequently, the third hypothesis examines the (III) significant differences in visual patterns based on expertise level within the real estate sector.

Overall, this study investigates the relationship between visual attention and product evaluation in the real estate sector. It aims to overcome several limitations of previous studies, such as social desirability bias in subjective responses and the lack of integration of objective physiological measures, which restrict our holistic understanding of consumer behavior in the real estate domain. Specifically, the objective is to analyze the relationship between visual attention to online real estate property information and the evaluation of these properties, addressing the three aforementioned hypotheses.

## 2. Methodology

This study employed a field study design in which participants observed a visual stimulus using eye-tracking technology and completed a questionnaire regarding their

perception of the stimulus. Consequently, two types of information were collected from each participant: (1) the visual patterns exhibited and (2) the subjective perception of the stimulus. Additionally, sociodemographic information was gathered to address intrasubject variables of interest in the study.

### 2.1. Subjects

A total of 21 participants (mean age = 38.8, SD = 11.2) comprised the sample in this study. All participants had a homebuyer profile, with ages ranging from 28 to 55 years. These participants were selected through a recruitment process initiated from a pool of volunteers. From this initial group, individuals who met two essential inclusion criteria were selected: having optimal vision with the best possible correction and possessing a genuine interest in purchasing a home. The first criterion aimed to control for one of the study variables: vision. The second criterion ensured a sample relevant to the study context: active engagement in the process of home searching for purchase. These data were reported by the participants (incorrect/correct without support/correct with support vision and none/medium/high interest in purchase). Additionally, efforts were made to ensure that gender and profession (expert: studies and work related to architecture/engineering; non-expert: other studies) were balanced. Table 1 displays the most relevant characteristics of the sample.

**Table 1.** Sample characteristics reported independently.

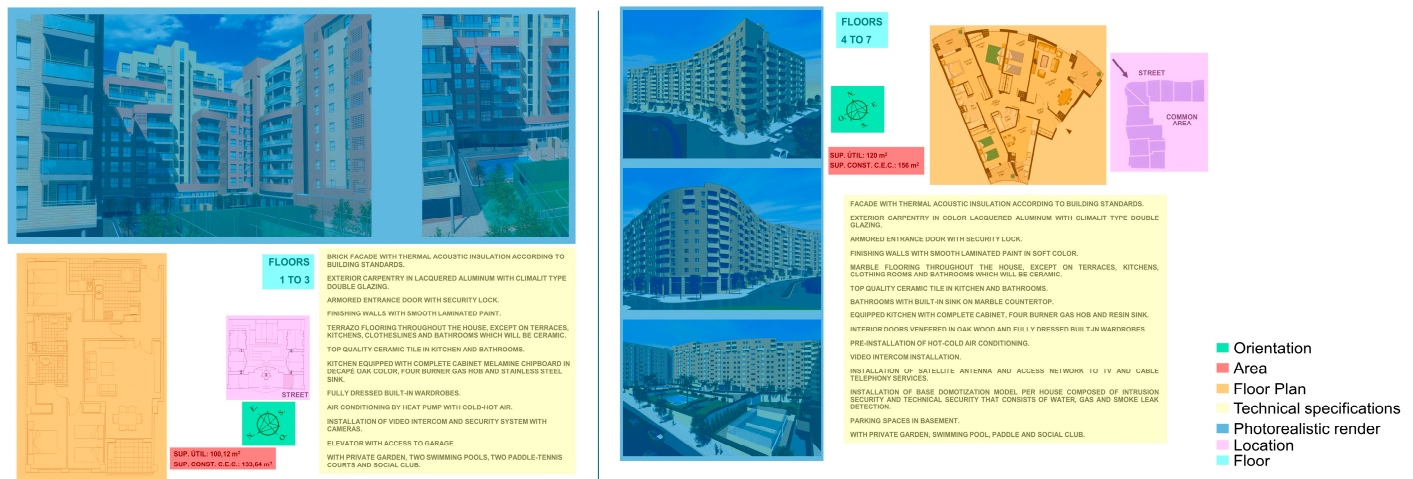
| Gender                | Profession                | Age                 | Interest on the Purchase of a Home | Vision                                |
|-----------------------|---------------------------|---------------------|------------------------------------|---------------------------------------|
| Male<br>11 (52.38%)   | Expert<br>11 (52.38%)     | <30<br>7 (33.33%)   | None<br>-                          | Incorrect<br>-                        |
| Female<br>10 (47.62%) | Non-expert<br>10 (47.62%) | 30–40<br>4 (19.05%) | Medium<br>8 (38.1%)                | Correct without support<br>5 (23.81%) |
|                       |                           | 40–50<br>6 (28.57%) | High<br>13 (61.9%)                 | Correct with support<br>16 (76.19%)   |
|                       |                           | >50<br>4 (19.05%)   |                                    |                                       |

The process of searching for a home to purchase is not immediate. Typically, buyers tend to consider a set of homes before making a purchasing decision. Based on the main sales portals, it is estimated that buyers visit between 8 and 10 homes before the moment of purchase, viewing an average of 4 homes online [43]. To approximate the experimental situation to a real-world home search scenario, each of the 21 participants evaluated 4 different homes. Therefore, the total number of cases analyzed was 84 ( $21 \times 4$ ). However, 4 cases (2 from one participant and 2 from another) were excluded due to errors in the calibration of the eye-tracking device. This illustrates why each subject evaluated more than one home.

### 2.2. Stimuli

The stimulus set consisted of a collection of eight different visual stimuli depicting real estate properties. Each stimulus presented information about a real home as published on real estate websites. Therefore, the information contained in each stimulus pertained to a property currently for sale in Spain. For each of these homes, a final image was created (dimensions of  $1344 \times 1008$  pixels, with a resolution of 96 pixels per inch), following the schema outlined in Figure 1. Thus, each stimulus included information on the photorealistic render of the finished construction, the floor plan layout of the dwelling, its orientation relative to the cardinal plane, usable and constructed dimensions of the home, the floor level of the dwelling, technical specifications of the construction, and its location relative to other units in the development. The type of stimulus used is highly complex as it contains elements of various natures (graphic, schematic, textual, etc.). Consequently, the subject's

corner-to-center viewing patterns [44,45], combined with the consistent distribution of the different elements constituting the stimuli, could bias the results. To minimize this potential confounding effect, the position of these elements within the stimuli was randomized (see Figure 1).



**Figure 1.** Examples of the stimuli used, with varying arrangements of their constituent elements. Note that the dimensions of these elements remained consistent across all stimuli.

To select the final eight dwellings that constituted the stimuli, a preliminary Focus Group was conducted involving four subjects (two architects and two non-architects) who were potential home buyers. In this Focus Group, (1) a set of fundamental characteristics specific to real estate promotions [46] was identified, and (2) a group of 48 homes available for sale at the time of the study was evaluated using the Affinity Diagram technique [47]. Through this technique, homes were grouped based on similar characteristics, and a representative home was selected from each group, resulting in eight typical homes. A diverse selection of stimuli was chosen to encompass the seven included elements.

### 2.3. Measures

**Stimulus Viewing Pattern.** Eye movements were recorded using the Tobii TX300 eye tracker (Tobii Technology AB, Stockholm, Sweden), a high-frequency (300 Hz) 2-dimensional device featuring a 24" monitor with an under-screen eye-tracking bar. This bar captures gaze behavior information every millisecond during the observation of an image on the screen. To analyze the eye-tracker data, Areas Of Interest (AOIs) were defined for each stimulus, following a methodology [48] similar to that used in other eye tracking studies [49,50]. The AOIs were consistent across all stimuli, with their locations varied within the image to avoid visualization biases that could affect the results. The criteria for delineating the AOIs were based on their correspondence with the nature of each element within the image, resulting in seven distinct areas as indicated in Figure 1: (1) house orientation, (2) area corresponding to house size, (3) house layout plan, (4) quality specifications, (5) image of a photorealistic render, (6) house location relative to others on the same floor, and (7) floor level where the house is situated. Two eye-tracking metrics were obtained: First Fixation Time (FFT) and Total Fixation Duration (TFD). The first metric, FFT, refers to the time elapsed from the start of viewing until the participant first directed their gaze towards each AOI in the image. On the other hand, TFD represents the total time the subject fixated on each AOI during the entire viewing period. Both metrics were expressed in milliseconds and reported directly as output from the data collection device.

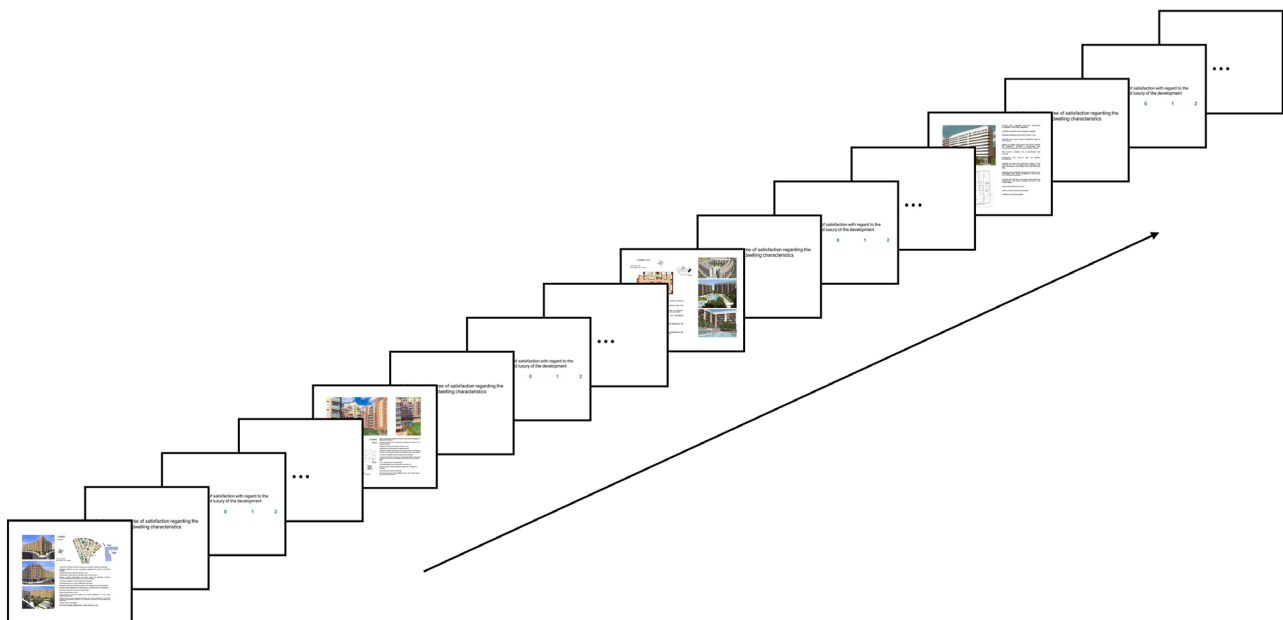
**Stimulus Evaluation.** To assess the evaluation of each dwelling, participants were asked to provide their subjective perceptions. A questionnaire was presented for each visualization, gathering perceptions on the design attributes of each stimulus. This questionnaire consisted of a 5-point Likert scale (minimum value −2: low satisfaction and

maximum value 2: high satisfaction) that assessed satisfaction with nine characteristics of interest in a home, as identified in a previous Focus Group [46]: (1) quality and finishes of the dwelling, (2) size of the dwelling, (3) dwelling floor level, (4) bright and outdoor orientation of the dwelling, (5) flexible layout, (6) peaceful atmosphere, (7) smart and secure character, (8) privacy, and (9) original and luxurious character. In order to develop the questionnaire, an initial statement was asked: “Indicate your degree of satisfaction regarding the following dwelling characteristics”. Subsequently, sentences were displayed on the screen to rate each of the characteristics of the property independently, for example, “rate your level of satisfaction with regard to the originality and luxury of the development”. Additionally, the questionnaire included an initial part that was asked at the beginning of the experimentation. This contained sociodemographic questions concerning age, gender, expertise level in architecture, and interest in purchasing a home.

#### 2.4. Development of Study

Initially, participants entered the study and responded to initial sociodemographic questions. Subsequently, they comfortably seated themselves approximately 60 cm from the monitor and the Tobii TX300 eye-tracker—according to the manufacturer’s instructions “<https://www.tobii.com/> (accessed on 8 January 2024)” —, maintaining a frontal plane relative to the screen and the device. Automatic eye-tracking calibration then commenced (with a maximum calibration error of 30 pixels in diameter), involving the participant following five points with their gaze without moving their head.

The eye-tracking experience began with a 25-s observation of the first stimulus. Subsequently, while still observing the screen, questionnaire prompts appeared individually. This procedure was carried out four times consecutively. That is, each housing stimulus was alternated with each of the corresponding evaluation questions (Figure 2). The assignment of the four stimuli and the order of presentation for each subject was randomized, with the average time spent on each being approximately 15 min.



**Figure 2.** Alternation of housing stimuli with the corresponding evaluation questions presented.

Throughout the procedure, Tobii Studio 3.2.1 software was utilized, essential for processing the data obtained from the Tobii TX300 eye tracker, enabling the combined presentation of stimuli and questionnaire. The software operates with 3 hierarchical levels: project, tests, and images. Thus, 1 project was developed, consisting of 8 tests. Each test featured a single dwelling stimulus, comprising 11 images, with the first containing the stimulus and the rest containing questionnaire prompts. The project was configured so

that each subject was presented with only four randomized tests, including one additional image at the end of each test to indicate the beginning of the evaluation of the next stimulus and the end of the experiment.

### 2.5. Data Processing

For the statistical data analysis, IBM SPSS software (v.27.0.1) was used. The data analysis comprised several phases corresponding to the hypotheses formulated, as outlined in Table 2.

**Table 2.** Summarizes the statistical treatment applied.

| Hypotheses | Physiological                | Study Variables Assessment         | Intrasubject                   | Statistical Test               |
|------------|------------------------------|------------------------------------|--------------------------------|--------------------------------|
| I          | FFT AOI (x7)<br>TFD AOI (x7) | design attributes assessments (x9) | -                              | Spearman Correlation Test      |
| II         | FFT AOI (x7)<br>TFD AOI (x7) | design attributes assessments (x9) | Gender (Male/Female)           | Mann Whitney U comparison test |
| III        | FFT AOI (x7)<br>TFD AOI (x7) | design attributes assessments (x9) | Profession (expert/non-expert) | Mann Whitney U comparison test |

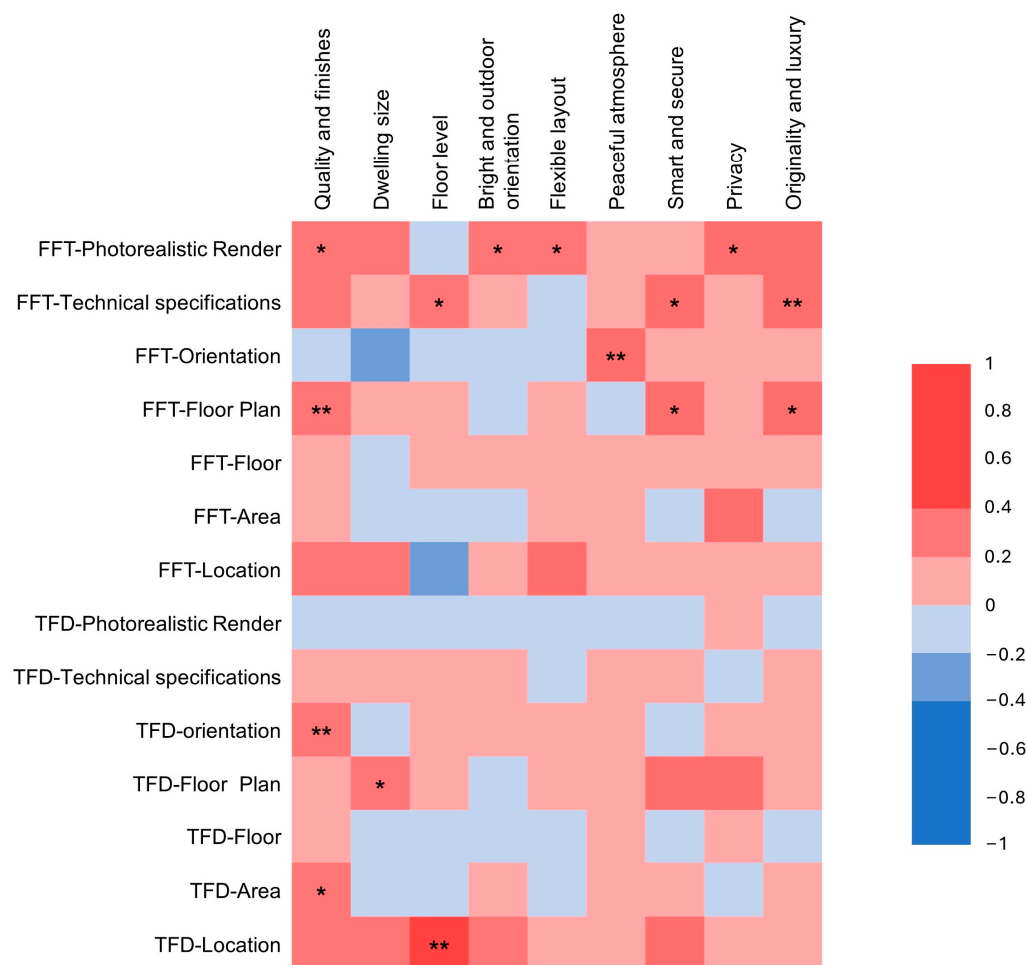
Comparative and correlations non-parametric statistical tests were conducted based on the normality assumption verification of the visual pattern and subjective ratings. The Kolmogorov–Smirnov test with Lilliefors significance correction was used for this purpose, revealing a non-normal distribution for each analyzed variable. A significance level of  $<0.05$  was applied to all tests. The Spearman correlation developed the confidence interval by estimating the variance with the method proposed by “Fieller, Hartley and Pearson” using the Fisher Z transformation [51,52]. The Mann–Whitney U comparison developed the confidence interval through the “Monte Carlo” method for Bootstrap analysis [53]. As for the effect size index, we took the correlation coefficient itself [54] and calculated  $r$  for all significant Mann–Whitney test results [55].

## 3. Results

### 3.1. Hypothesis I: There Is a Relationship between Subjects’ Viewing Pattern and Their Evaluation of the Observed Houses

In this section, we analyzed whether there was a correlation between the FFT and TFD variables obtained from eye tracking, and the subjective evaluation of the presented houses. For this purpose, the Spearman correlation coefficient was selected as the statistical test.

The results, depicted in Figure 3, show that subjective evaluations were indeed related to the TFD on the stimulus. Specifically, there was a significantly positive correlation between the evaluation of spaciousness and TFD-Floor Plan ( $r_{s(78)} = 0.337$ ,  $p = 0.023$ ,  $IC_{95\%} [0.040–580]$ ), between the evaluation of quality and finishes with TFD-orientation ( $r_{s(78)} = 0.358$ ,  $p = 0.002$ ,  $IC_{95\%} [0.136–546]$ ) and TFD-Area ( $r_{s(78)} = 0.291$ ,  $p = 0.020$ ,  $IC_{95\%} [0.041–506]$ ), and between the evaluation of the floor and TFD-Location ( $r_{s(78)} = 0.484$ ,  $p = 0.002$ ,  $IC_{95\%} [0.181–704]$ ). These latter two subjective evaluations also showed positive correlations with FFT. Specifically, there was a correlation between the evaluation of quality and finishes with FFT-Floor plan ( $r_{s(78)} = 0.390$ ,  $p = 0.001$ ,  $IC_{95\%} [0.169–574]$ ) and FFT-Photorealistic Render ( $r_{s(78)} = 0.249$ ,  $p = 0.045$ ,  $IC_{95\%} [-0.002–471]$ ), and between the evaluation of the floor and FFT-Technical specifications ( $r_{s(78)} = 0.233$ ,  $p = 0.037$ ,  $IC_{95\%} [0.008–436]$ ).



**Figure 3.** Summary diagram of the results obtained from the correlation test, where the color scale represents the degree of correlation from  $-1$  to  $1$ . Note that one and two asterisks indicate a  $p$ -value  $< 0.05$  and  $< 0.01$ , respectively.

Furthermore, the First Fixation Time correlated with the rest of the subjective evaluations: FFT-Photorealistic Render with evaluation of bright and outdoor orientation ( $r_{s(78)} = 0.303$ ,  $p = 0.032$ ,  $IC_{95\%}$  [0.016–485]), flexible distribution ( $r_{s(78)} = 0.305$ ,  $p = 0.013$ ,  $IC_{95\%}$  [0.059–517]), and privacy ( $r_{s(78)} = 0.254$ ,  $p = 0.041$ ,  $IC_{95\%}$  [0.004–475]); FFT-Technical specifications with evaluation of intelligence and security ( $r_{s(78)} = 0.277$ ,  $p = 0.013$ ,  $IC_{95\%}$  [0.054–473]) and originality and luxury ( $r_{s(78)} = 0.305$ ,  $p = 0.006$ ,  $IC_{95\%}$  [0.085–497]); FFT-orientation with evaluation of peaceful atmosphere ( $r_{s(78)} = 0.329$ ,  $p = 0.003$ ,  $IC_{95\%}$  [0.107–520]); and FFT-Floor plan with evaluation of intelligence and security ( $r_{s(78)} = 0.244$ ,  $p = 0.037$ ,  $IC_{95\%}$  [0.008–455]) and originality and luxury ( $r_{s(78)} = 0.253$ ,  $p = 0.031$ ,  $IC_{95\%}$  [0.018–462]).

### 3.2. Hypothesis II: There Are Significant Differences in the Viewing Pattern Based on Participants' Gender

In this section, we analyzed whether there were differences in eye-tracking metrics for each AOI and subjective perception of the houses between men and women. For this purpose, the non-parametric Mann–Whitney U test was applied.

The results, presented in Table 3, demonstrate that gender significantly affects the time until the first fixation. Specifically, men and women showed a TFF on the area that was statistically significant ( $U = 92.5$ ;  $p = 0.037$ ,  $r = 0.3478$ ), with a 95% confidence interval for the median reaction times in each group (group men: [0.2465–2.184]; group women: [0.1306–0.4427]). In addition, the photorealistic FFT-Render between the two groups approached statistical significance

( $p = 0.059$ ). On the other hand, there were no differences by gender in TDF. However, there were near-significant differences in TFD-orientation ( $p = 0.057$ ).

**Table 3.** Comparative results by genders. Note that one asterisk indicates a value  $< 0.05$ .

|                              |        | Mean Rank | Sum of Rank | U     | $p$     |
|------------------------------|--------|-----------|-------------|-------|---------|
| FFT-Photorealistic Render    | Male   | 29.5      | 1180        | 360   | 0.059   |
|                              | Female | 38.6      | 965         |       |         |
| FFT-Technical specifications | Male   | 43.38     | 1822        | 677   | 0.244   |
|                              | Female | 37.32     | 1418        |       |         |
| FFT-Orientation              | Male   | 36.59     | 1427        | 647   | 0.329   |
|                              | Female | 41.47     | 1576        |       |         |
| FFT-Floor Plan               | Male   | 35.86     | 1398.5      | 618.5 | 0.623   |
|                              | Female | 38.31     | 1302.5      |       |         |
| FFT-Floor                    | Male   | 33.59     | 1310        | 530   | 0.141   |
|                              | Female | 40.91     | 1391        |       |         |
| FFT-Area                     | Male   | 21.6      | 453.5       | 92.5  | 0.037 * |
|                              | Female | 14.17     | 212.5       |       |         |
| FFT-Location                 | Male   | 18.62     | 391         | 155   | 0.936   |
|                              | Female | 18.33     | 275         |       |         |
| TFD-Photorealistic Render    | Male   | 39.38     | 1614.5      | 752.5 | 0.960   |
|                              | Female | 39.64     | 1466.5      |       |         |
| TFD-Technical specifications | Male   | 24.29     | 631.5       | 213.5 | .441    |
|                              | Female | 21.24     | 403.5       |       |         |
| TFD-orientation              | Male   | 33.28     | 1264.5      | 523.5 | 0.057   |
|                              | Female | 42.85     | 1585.5      |       |         |
| TFD-Floor Plan               | Male   | 22.96     | 597         | 246   | 0.982   |
|                              | Female | 23.05     | 438         |       |         |
| TFD-Floor                    | Male   | 20.1      | 522.5       | 140.5 | 0.626   |
|                              | Female | 18.21     | 218.5       |       |         |
| TFD-Area                     | Male   | 32.68     | 1274.5      | 480.5 | 0.923   |
|                              | Female | 32.22     | 805.5       |       |         |
| TFD-Location                 | Male   | 18.4      | 460         | 135   | 0.626   |
|                              | Female | 20.25     | 243         |       |         |

### 3.3. Hypothesis III: There Are Significant Differences in the Viewing Pattern Based on the Level of Expertise in the Sector

In this section, we analyzed whether there were differences in eye-tracking metrics for each AOI and subjective perception of the houses between experts and non-experts. For this purpose, the non-parametric Mann–Whitney U test was applied.

The results, presented in Table 4, demonstrate that expertise level did not lead to differences in the time until the first fixation (all  $p > 0.050$ ). However, there were differences in terms of expertise level for the TDF. Specifically, there were statistically significant differences in TFD-Photorealistic Render between experts and non-experts in the field of architecture ( $U = 528$ ,  $p = 0.027$ ,  $r = 0.2508$ ), with a 95% confidence interval for the median reaction times in each group (group experts: [5.1965–8.0816]; group non-experts: [3.498–6.4529]).

**Table 4.** Comparative results between expertise levels. Note that one asterisk indicates a value < 0.05.

|                              |            | Mean Rank | Sum of Rank | U     | p       |
|------------------------------|------------|-----------|-------------|-------|---------|
| FFT-Photorealistic Render    | Non-expert | 32.78     | 1213        | 510   | 0.916   |
|                              | Expert     | 33.29     | 932         |       |         |
| FFT-Technical specifications | Non-expert | 41.73     | 2003        | 709   | 0.562   |
|                              | Expert     | 38.66     | 1237        |       |         |
| FFT-Orientation              | Non-expert | 37.89     | 1705        | 572.5 | 0.598   |
|                              | Expert     | 40.56     | 1298        |       |         |
| FFT-Floor Plan               | Non-expert | 38.05     | 1750.5      | 572.5 | 0.579   |
|                              | Expert     | 35.2      | 950.5       |       |         |
| FFT-Floor                    | Non-expert | 38.72     | 1781        | 542   | 0.367   |
|                              | Expert     | 34.07     | 920         |       |         |
| FFT-Area                     | Non-expert | 20.19     | 424         | 122   | 0.254   |
|                              | Expert     | 16.13     | 242         |       |         |
| FFT-Location                 | Non-expert | 19.1      | 401         | 145   | 0.688   |
|                              | Expert     | 17.67     | 265         |       |         |
| TFD-Photorealistic Render    | Non-expert | 34.76     | 1599        | 518   | 0.027 * |
|                              | Expert     | 46.31     | 1482        |       |         |
| TFD-Technical specifications | Non-expert | 22.29     | 579.5       | 228.5 | 0.671   |
|                              | Expert     | 23.97     | 455.5       |       |         |
| TFD-orientation              | Non-expert | 36.7      | 1578        | 632   | 0.549   |
|                              | Expert     | 39.75     | 1272        |       |         |
| TFD-Floor Plan               | Non-expert | 25.69     | 668         | 177   | 0.108   |
|                              | Expert     | 19.32     | 367         |       |         |
| TFD-Floor                    | Non-expert | 19.59     | 431         | 174   | 0.953   |
|                              | Expert     | 19.38     | 310         |       |         |
| TFD-Area                     | Non-expert | 30.5      | 1098        | 432   | 0.330   |
|                              | Expert     | 35.07     | 982         |       |         |
| TFD-Location                 | Non-expert | 18.29     | 384         | 153   | 0.646   |
|                              | Expert     | 19.94     | 319         |       |         |

#### 4. Discussion

The present study suggests that the visual observation pattern of information about a house is related to the evaluation of that house, with moderate correlations between these variables. Only the time to first fixation on the surface element and the fixation duration on the image element showed differences based on gender and expertise level.

Interpreting these results, it was found that all subjective ratings were positively related to the time elapsed until the first fixation on at least one of the AOIs containing the visual stimulus of the house. Most of these correlations are with AOIs that stand out either due to their graphical nature, such as the image, floor plan, or orientation, or due to familiarity with the type of information like the written message in the description. Previous research supports these findings, as it categorizes stimulus elements into bottom-up and top-down factors based on the type of attention they elicit in the observer [30,56]. Bottom-up factors are characteristics of the stimulus that automatically attract the subject's visual attention, often due to saliency, while top-down factors are elements towards which the subject voluntarily and consciously directs attention, typically to accomplish a task or goal.

It is important to note that the fixation duration on certain AOIs only correlates with three subjective ratings: quality and finishes, floor plan, and spaciousness. Among all ratings, these three show a direct relationship with the information presented in the visual

stimulus. The rest have a more subjective nature or require interpretation with respect to the observed information, thus involving a greater cognitive load [57].

Eye-tracking information did not differ significantly between men and women. While there is some consensus in the literature that visual strategies for navigation differ between genders [58,59] and that women have a more exploratory visual pattern in passive situations [34], the present study focuses on duration parameters rather than quantity [60]. Given the complex nature of the stimulus used, it is reasonable to assume that attention to different stimulus elements is similarly captured by both men and women. This aligns with recent studies that suggest visual gender differences occur when there is a social presence of a real person [61]. Regarding the difference in gaze fixation time to the surface AOI (a non-graphical area containing mathematical notation about the square meters of the house) between genders, it may be justified by the fact that, traditionally, girls show less motivation for mathematical characters [62].

Lastly, the difference in fixation duration on the image AOI between participants with expertise and those without expertise in the field is notable. Non-experts spent more time than experts. Prolonged eye fixation time can be analyzed in two different ways. On one hand, it could be related to information extraction and active cognitive processing. In this sense, prior experience facilitates information comprehension [63], which would justify why architects' familiarity with construction images entails a shorter gaze fixation time on this type of content for processing. On the other hand, a longer fixation duration could also suggest a higher level of interest in the object in question. According to this, not only do adults show physiological responses like pupil dilation when processing novel information [64] but there is also a preference for novel objects over familiar ones, as reflected in gaze fixation time [65].

Caution is advised in interpreting the results due to potential type I or II errors and the risk of spurious correlations post-statistical testing. Additionally, while the overall sample was balanced in terms of profession and gender, the sample's accessibility resulted in a higher percentage of male experts at 63.63% (7 men versus 3 women out of a total of 11 experts), potentially influencing gender differences. Methodologically, the use of a 24" monitor in eye-tracking restricted visualization to A4 size, impacting peripheral perception. Eye-tracking systems only register the center of the visual gaze (known as foveal vision) and cannot capture the periphery of the visual gaze (known as profoveal vision). This limitation is critical, as the perception of peripheral objects is usually below conscious awareness, which can significantly affect immediate reactions and subsequent behaviors [66]. Furthermore, this tool only reports a specific point of gaze fixation [67]. Although our research has complemented this with subjective evaluations of the dwelling, future studies could address associated emotions [17] or cognitive biases that influence visual patterns.

## 5. Conclusions

In this study, we explored the relationship between consumers' visual attention patterns during online house sales information visualization and their subjective evaluation of these properties. Eye-tracking technology was used to capture objective metrics of participants' visual behavior while viewing visual stimuli of houses. The findings revealed significant correlations between all subjective ratings and the time elapsed until the first fixation on different areas of interest in the stimulus. Moreover, the fixation duration on some areas of interest also correlated with ratings involving direct processing of observed information. Additionally, differences based on gender and participants' level of expertise in architecture were investigated. Some significant differences in visual behavior were found between men and women, particularly between architecture experts and non-experts, especially in the initial fixation time and fixation duration on key areas of the images.

These results have important implications for the design and presentation of online house sales information. Visual attention can influence the perception of a house's features, thus impacting purchasing decisions. Understanding how people visualize and process

visual information about houses can help real estate marketing professionals improve their online product presentations.

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