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Bachelor thesis

Properly about property floor plans:

Eye-tracking study on an impact of real estate floor plan design

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Abstract

Objectives: In a rapidly evolving technological world, real estate professionals need to leverage persuasive design of layout visualizations to effectively enhance home buyers' purchase intention. This study focused on evaluating the impact of floor plan design formats (2D and 3D) and elements (base, color and furniture) on gaze behavior (viewing duration, fixation duration, number of fixations and number of saccades) to facilitate property purchase intentions. By integrating insights from real estate, marketing and gaming literature, the research identified key factors moderating this relationship, such as spatial orientation in 2D and 3D and familiarity with floor plans and in-game maps. Additionally, based on landscape preference research, the impact of the floor plan design was explained by viewers' perceptions of its complexity, coherence, and legibility. **Methods:** The study involved 180 participants from a convenience sample and used a 2x3 experimental design with Tobii Pro 3 eye-tracking glasses and a questionnaire. Participants, including students and adults, were asked to view the floor plans for an unlimited time and evaluate them. The eye-tracking data were combined with questionnaire responses for analysis. **Results:** The study found no evidence that gaze behavior mediates the relationship between floor plan design (format and elements) and purchase intention. The research suggests that 3D floor plans have the most significant influence on purchase intention, with furniture elements making a substantial difference for individuals with varying level of spatial orientation in 2D and 3D. The 2D floor plans elicited the most organized viewing patterns, potentially enhancing the mental image of the property. It was concluded that floor plans should primarily facilitate wayfinding and be coherent; grouping rooms of similar utility by colors or textures, limited to three distinct ones, should yield optimal results for persuading home buyers. **Implications:** Theoretical implications suggest that landscape preference literature might be applied to the context of maps and floor plans. Furthermore, the real estate industry could benefit from additional research on property layout visualizations to meet the requirements of todays' customer.

Keywords: Floor plan, 2D and 3D format, real estate, eye-tracking, visual attention, purchase intention

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Introduction

The emergence and popularization of the technology in recent decades have profoundly transformed the dynamics between sellers and buyers in the United States real estate market. Conventional property-selling means such as paper catalogs were replaced by easily updatable web pages on commercial multiple listing service (MLS) sites in the early 2000s. This shift significantly enhanced the flexibility of the search process, enabling buyers to tailor it to their specific needs, or refine their property requirements (Martens & Koutamanis, 2003). Given that purchasing a house is one of the most important financial decisions of U.S. households (Li & Yavaş, 2015) and conversely one of the greatest financial risks (Benefield et al., 2009), this increased flexibility has empowered house seekers to make much more informed decisions. They are less constrained by predetermined property choices, location limitations, and the periodicity of analog property catalogs. Given the easy access home seekers now have to vast amounts of information, meeting the heightened standards of today's buyers requires real estate agents to ensure a thorough information provision and effectively employ persuasive techniques.

As previous studies suggest, the skill of utilizing adequate media assets allow brokers to successfully capture the visual attention of potential property buyers already at the pre-purchase stage. Research by Seiler et al. (2012) indicates that heightened visual attention of potential home buyers is directed towards pictorial representation of the property rather than textual descriptions. Further studies have analyzed real estate listings in the context of the quality (Hebdzyński, 2023; Luchtenberg et al., 2018) and quantity (Gay & Zhang, 2015) of property pictures, as well as their impact on the time a property remains on the market (Benefield et al., 2009). However, understudied is the persuasive power of the property layout displayed on the real estate webpages and the influence of its design on visual attention and potentially purchase intention. Additionally, there is a lack of research isolating these effects from the homebuyers' socio-economic factors to determine which floor plan type would be most persuasive in a standardized environment where financial reach and requirements are already met.

The development of the interior digital-reconstruction technology, alongside the emergence of various design formats (2D and 3D) and added elements (property outline, color/textures, and fixtures/furniture), has provided real estate agents with ample opportunity to showcase properties in the most favorable light and persuasively highlight their aspects.

However, it is important to recognize that while these technological advancements offer significant benefits, their effectiveness in capturing and keeping attention of potential buyers also hinges on the clarity and accessibility of the presented information. The viewer's perception of how complex, organized, and easy to navigate the floor plans are is crucial. This perception may be influenced by their familiarity with the concept and symbolism of the layouts, which, for the younger generation, may be enhanced or supplemented by their experience with map navigation in video games. Ensuring that these tools are designed with the user's perspective in mind, considering buyers' spatial orientation skills necessary for successful interpretation of the space, is crucial for maximizing the impact of visualizations. Therefore, this investigation focuses on the practical problem of which floor plan types can most effectively influence the potential buyers' visual attention and, in turn, potentially increase the purchase intention to buy the viewed property. To isolate the impact of the floor plan design this study will hold socio-economic factors constant.

This research aims to improve the understanding and quantify potential homebuyers' gaze patterns using eye-tracking equipment. In a 2x3 experimental design, the study will investigate the differences in gaze patterns evoked by floor plans of different design formats (2D and 3D) and displayed elements (base, with colors/textures, and with fixed furniture). Drawing from the literature on landscape preferences, the gaze behavior of the participants will be cross-examined with their perception of the complexity, coherence, and legibility of the viewed property visualization. Additionally, guided by suggestions from wayfinding literature, participants' spatial orientation, past experience with property search, and maps in video games will be evaluated in the context of their impact on gaze behavior and ultimately, purchase intention evoked by the specific floor plan.

The following sections of the report outline the steps of the investigation. First, the relevant real estate, landscape, wayfinding, and video gaming literature is presented as a base for formulated hypotheses regarding gaze behavior and floor plan type preference. Next, the methods section illustrates the experimental design alongside the materials used and developed scales. This is followed by the results of the investigation, starting with descriptive statistics and further organized by the hypotheses. The conclusions, practical and theoretical implications, as well as recommendations for future research, are summarized in the last section of the paper.

1. Theoretical framework

1.1 Purchase orientation process in the real estate market

The rapid digitalization of the homebuyers' pre-search processes has presented both challenges and opportunities to sellers. On one hand, transactions are subject to more negotiation as prospective buyers become well-informed about the market and its offerings. On the other hand, thanks to the flagship feature of today's United States real estate industry, the multiple listing service (MLS), properties on sale receive much wider exposure with little to no effort from the seller's side (Li & Yavaş, 2015). Despite the ease of access, the literature recognizes significant information asymmetry between the sell and buy sides of the housing market transaction. As Hebdzyński (2023) points out, assessing the true state of a property is difficult for home seekers, as the in-person visiting process requires substantial monetary and time resources and specialized knowledge. Therefore, the information provided in real estate listings should give homebuyers a comprehensive understanding of the property's condition. Adequately leveraging the elements of the listing to attract and anchor potential buyers becomes the ultimate goal of sellers.

To fulfill this aim, one should understand the hierarchy of needs of homebuyers in the purchase orientation phase. The National Association of REALTORS® Research Group (2022) identified detailed information about properties for sale, photos, and floor plans as the three necessary elements of real estate listings that influence buyers' decision-making. Without this pragmatic information, buyers would be unable to make informed decisions. However, this value hierarchy does not capture how individuals familiarize themselves with a property and form their initial impressions of it. Eye-tracking studies on online listing websites by Seiler et al. (2012) revealed that prospective homebuyers' gaze is primarily fixed on visual depictions of the property and only secondarily on textual descriptions. Therefore, with information such as an address, square footage, construction type, and rent or sell price considered standard by most MLS websites (Zhang, 2014), the influential difference for purchase intention is established by the presence of visual data. Pictures and floor plans allow individuals to envision and strategically plan their lives within the dimensions of a prospective accommodation. Facilitating the decision-making process, layout visualizations can help avoid or reduce conflict resulting from the building layout or structure and the misaligned planned use of the space by new tenants (Martens & Koutamanis, 2003). Reducing information uncertainty through visual means, therefore, presents an opportunity for real estate professionals to attract potential buyers.

1.2 Floor plan design elements and formats

Identified as a decision-making support tool that reduces home seekers' hesitancy towards purchase, floor plans have become increasingly important over the last decade in the U.S. real estate market. A floor plan can be defined as "a scale diagram of a room or suite of rooms viewed from above" (Floor Plan, 2024). It includes key structural features such as walls, doors, and windows, showcasing their proportional relationships and spatial distribution. Additionally, the floor plan may incorporate notations, dimensions, and symbols to convey specific details about room sizes, door openings, total square footage, and other relevant measurements. In this way, the floor plan offers a comprehensive and standardized visual guide for understanding the organization and flow of spaces within a building.

To reinforce purchase decisions, real estate professionals can choose from multiple, progressively more detailed floor plan design options. The most fundamental form of visual representation depicts only the dimensions, walls, entrances, and windows of the property in a black-and-white scheme. Depending on the selling offer, this base plan can be enriched with fixed furniture or fixtures, defined as "equipment that is fixed inside a house or building and is usually sold with it" (Fixture, 2024). Additionally, to improve the understanding of the space and catch the attention of potential buyers, many real estate layouts use colors and textures (Von Castell et al., 2014). Furthermore, beyond the three levels of graphical complexity (base, with fixed furniture, and with colors and textures), property sellers can opt for either 2D or 3D formats of the interior layout. The multi-dimensional version of the floor plan employs perspective drawing techniques, tilting the property content to present the depth of spatial structures such as walls and furniture (Zheng & Hsu, 2021). In contrast to the standard floor plan, the commercialized 3D version offers a space for showcasing potential utilization of living spaces, in addition to fixture elements, using seller-proposed furnishing models. In conclusion, an adequate combination of the floor plan format (2D vs. 3D) and their design elements (base, with fixed furniture, and with colors and textures) can attract visual attention and facilitate optimal persuasion of homebuyers.

1.3 Gaze behavior and the purchase intention

To understand the potential application of eye-tracking technology in real estate research, it's essential to grasp the key terminology. Eye-tracking methodology in this context focuses on three concepts related to eye motion and time: *saccades*, *fixations*, and *viewing*. *Saccades* refer to large scanning movements that typically occur 3-4 times every second (Seiler et al., 2012). *Fixations* are the periods when the eyes are relatively still, focused on a specific point. The time it takes an individual to view a stimulus is termed *viewing duration*. Together, viewing time and the number of fixations indicate the efficiency of completing a task (Van Der Lans & Wedel, 2017). Fixation duration, on the other hand, can suggest how difficult a task was, with longer fixation times correlating with greater effort (Van Der Lans & Wedel, 2017). Monitoring eye movements within these dimensions provides a quantifiable picture of human visual attention.

Eye-movement research is gaining prominence in real estate brokerage. As Van Der Lans and Wedel (2017) emphasized, it is nearly impossible for individuals to suppress eye movements to regions that attract visual attention. Therefore, unlike surveys that focus on participants' stated preferences, physiological measures of eye movements quantified in eye-tracking studies can confirm or reveal subconscious attentional patterns underlying real-time engagement with property visualizations (Seiler et al., 2012). To avoid cognitive overload from an abundance of visual stimuli, the eyes resort to selectively processing the area where the gaze is fixated (Just & Carpenter, 1980). Consequently, eye movements and prolonged fixation on specific areas of a floor plan can indicate the current search strategy and underlying evaluation of the property by the viewer.

Furthermore, literature in consumer psychology suggests that visual attention towards a layout mediates consumers' intention to purchase the property. The eye's fixation on a product option plays a crucial role in shaping preference towards it. In an inherent bias described by Simion and Shimojo (2006) as the gaze cascade effect, a prolonged gaze on a stimulus makes individuals like it more; the more they like it, the longer they look at it. This dual process with a feedback loop shapes the preference for the eventually chosen option. However, while gaze is a prerequisite for purchase consideration, it is not the final determinant of choice. The purchase decision depends on multiple internal (e.g., personal preferences, needs) and external factors (e.g., visual stimuli placement in the observed environment; see e.g., Atalay et al., 2012; Gidlöf et al., 2017). Nonetheless, as a comprehensive summary of eye-tracking studies in the marketing industry by Van Der Lans and Wedel (2017) suggests, visual attention mediates the effects of both internal and external aspects of the purchase decision process. Eye movements serve as an intermediary between the customer's search process and their choice (Van Der Lans & Wedel, 2017). Transferring these findings to the real estate field, it can be inferred that prolonged visual attention towards a chosen floor plan type signals increased cognitive processing of the displayed information, thereby enhancing potential purchase intention.

Expectations derived from these studies are summarized in the following hypotheses:

H1A: Gaze behavior will have a mediating effect on the relationship between floor plan format (2D, 3D), design elements (base, color, furniture) and property purchase intention.

H1B: Gaze behavior (prolonged floor plan viewing duration) will have a positive effect on property purchase intention.

As described earlier, gaze behavior is rarely fully controlled by the individual. It is influenced by personal characteristics, such as familiarity and preferences, as well as the environment (Gidlöf et al., 2017). Therefore, to complete the model of the relationship between visual attention connected to floor plan viewing and the intention to purchase the property, the following sections of the theoretical framework will detail which factors may influence home seekers' gaze behavior, consequently impacting their willingness to buy the property.

1.4 Format design (2D vs 3D) in spatial visualizations

The way people view floor plans depends on the format and content of the property visualization. A comprehensive study by Lei et al. (2014) found that a 2D electronic map "is more likely to produce fast browsing behavior" (p.153) than a 3D one, leveraging rapid eye movements. Scanning through the symbolic elements of the 2D space representation provides the viewer with a general impression of the space in a shorter time. The 3D electronic map, on the other hand, invokes "more focused browsing" (p.153, Lei et al., 2014). By prolonging fixation time, readers pay more attention to details in the environment, potentially increasing the memorability of the space (Snopková et al., 2019). The number and localization of fixation point clusters and scan paths superimposed on different floor plan formats can reveal the impact of their design on creating a mental representation and consequently on evaluating the property layout.

The variation in gaze patterns related to 2D and 3D floor plans stems from their differing levels of realism. The 3D property layout can be considered more intuitive and easier to interpret (Snopková et al., 2019), as its representation of furnishing elements closely mirrors reality. Visual cues in the form of recognizable property elements within these 3D floor plans guide the eyes towards crucial areas (landmarks), increasing the efficiency of mental navigation compared to 2D models (Dong & Liao, 2016). However, due to its increased number of details, including trivial ones, 3D layouts require higher cognitive effort to process and interpret the visual information (Dong & Liao, 2016; Liao et al., 2016). In this regard, 2D property representations offer higher clarity and usability, shortening viewing duration.

Therefore, the two design formats inform the following hypotheses of the investigation:

H2: Gaze behavior (the number of fixation points and saccades as well as fixations and viewing duration) will be lower for 2D than for 3D floor plan design viewers.

1.4.1 Design perception of complexity, coherence and legibility

Given that the layout of the property remains fixed, sellers can only attract and hold the attention of potential buyers by selecting an optimal floor plan design. To properly inform the consequent research steps, the investigation follows findings from marketing and landscape preference literature, which underscore the significance of aesthetic appeal and spatial arrangement in shaping individuals' impression of the property at the purchase orientation stage. The following section details the impact of floor plan design complexity, coherence, and legibility as crucial aspects manipulating perception of the format and design elements of the floor plan and consequently the gaze behavior and purchase intention.

First, design complexity offers a promising pathway for identifying differences in homebuyers' gaze and purchase intention. Kaplan's preference matrix and current studies unveil that people are inclined towards more complex, but not overcrowded spaces (Kaplan, 1975; Kuper, 2017; Shayestefar et al., 2022). The visual representation of the property should have enough details to engage potential homebuyers but not so many that it causes confusion. Design complexity can be understood in terms of the quantity, irregularity, dissimilarity, detail of objects, and asymmetry and irregularity of their placement (Pieters et al., 2010). Additionally, color diversity contributes to the perceived complexity of a scene (Shayestefar et al., 2022). The least complex floor plan will be the black-and-white 2D one conveying only the walls and entries' outlines, followed by the colored one and the one with fixtures. More complex will be the 3D floor plans, organized from the black-and-white base one with fixtures, the one with colors and textures, and the one detailing full proposed furnishing of the space. A greater number and variety of elements translate to more visual points to discover, ultimately increasing the number of fixation points and prolonging viewing duration (Shayestefar et al., 2022). Therefore, layouts of higher design complexity are believed to lower the efficiency and increase the mental effort of viewing the floor plan, and medium complexity designs should evoke higher intention to purchase the property.

Two other factors affecting viewers' gaze behavior are coherence and legibility of the floor plan design. Coherence refers to the orderly organization of the space. Following Kaplan et al.'s (1998) definition, floor plans can be considered coherent visual reconstructions as they divide large indoor spaces into chunks—rooms. However, true coherence is conveyed through the repetition of textures and colors. By using similar materials and textures within spaces of the same utilization purpose, floor plans sustain clear scan paths (Shayestefar et al., 2022), making it subconsciously easier to orient oneself in the plan. It is crucial to note that while using only one texture indicates high coherence, it is not engaging for the participant. Optimally, up to three textures should be used within visual landscape representations to uphold visual attention and leverage design coherence (Shayestefar et al., 2022). The least coherent floor plan type would be the 3D one displaying proposed furnishing, as it implements more than three texture types and colors. Within each format category, the black-and-white base floor plan would have a higher coherence score than the 3D one with proposed furniture, followed by layouts with colors and furniture and those with colors/textures. These visual design choices, combined with the previously described complexity level, facilitate wayfinding—legibility. Better organization of floor plan elements combined with repetitive colors fosters a good mental spatial representation of the property, fundamental for effective space interpretation and further navigation (Zheng & Hsu, 2021). This efficient processing of spatial information, evoked by higher legibility, correlates with fewer fixation points, shorter saccade lengths, and reduced viewing duration. Floor plans that should facilitate wayfinding the best would be the 2D ones with colors and fixtures and the 3D ones with colors, followed by the 2D and 3D base ones and the 3D ones with proposed furnishing

Despite designers' intentions, variations in individuals' cognitive processing result in diverse perceptions of property visualization designs compared to their original designs. Therefore, the complexity, coherence, and legibility of floor plan designs will be initially assessed for alignment with the intended design. This assessment will influence subsequent evaluations of the impact of format and design elements on visual attention and, in turn, the purchase intention.

1.5 Moderators – the role of familiarity and spatial orientation

Having detected that the realism, complexity, coherence and legibility of the floor plan design may impact the gaze behavior and consequently the purchase intention, it is crucial to point out the individual differences between homebuyers that can further influence the evaluation of property layout.

1.6.1 Familiarity with the floor plans

First detected factor is the familiarity with the floor plan as means for visualizing the property. As depicted by Dadi et al. (2014) sequential viewing of property layouts initiates a learning curve effect, gradually lowering the required cognitive effort and viewing duration needed for interpreting the information displayed. Therefore, prospective homebuyers who have familiarized themselves with either 2D or 3D floor plans during their last house or room search would require less effort in order to successfully extract and interpret information necessary for a purchase decision. The study of Seiler et al. (2012) confirms that experienced house seekers have shorter viewing duration, more limited scan path ranges, and pay attention to different elements within a floor plan than inexperienced group. Specifically, the investigation of Boumová and Zdráhalová (2016) points out that inexperienced floor plan users focus on room connections and the separation of private and public areas. In contrast, individuals with an architectural background, familiar with different floor plan types, value the effectiveness of property use, paying attention to the direct connection of the entrance with a living room (Boumová & Zdráhalová, 2016). In summary, higher familiarity with any form of floor plan can shorten viewing duration, decrease the number of fixation points and saccades, and guide the visual attention of the home seeker towards room connections over room utilization and arrangement.

In addition to experience from previous property searches, home seekers can become familiar with different floor plan types through video games. Moura and El-Nasr (2014) highlight that successful navigation, a fundamental aspect of video game mechanics, is achieved through various navigational systems, including schematic 2D and 3D maps displayed directly on the screen or in the menu. Although a direct connection between game experience and property layout evaluation has not yet been established within scientific literature, studies such as Green and Bavelier (2006) demonstrate a significant positive effect of gaming on visuospatial attention and localization accuracy. Moreover, gamers are found to perform better in way-finding tasks than non-gamers (De Leeuw et al., 2020; Murias et al., 2016), which can translate to differences in the comprehension of real estate floor plans.

The familiarity with floor plans stemming from either past home-seeking experience or exposure to in-game maps can be summarized in the following hypothesis:

H3A: Individuals familiar with reading floor plans will have fewer fixation points and saccades and shorter viewing and fixation durations than inexperienced individuals.

1.6.2 Spatial orientation in 2D and 3D

Another variable connected to the personal differences believed to influence the gaze behavior and purchase intention of the home seekers is spatial orientation. Spatial orientation, defined as the ability to perceive and maintain a sense of direction in relationship to objects in space, is crucial for the development of the "cognitive map upon which spatial decisions and strategies are based" (p. 154; Lei et al., 2014). Differences in the spatial comprehension can translate to varying preferences towards certain format of property layouts. The study by Smallman and Hegarty (2007) suggests that individuals with higher spatial orientation are prone to choosing 2D space visualizations of less complex design, as they are more adept at comprehending schematic maps. Home seekers viewing these floor plans may therefore have higher purchase intention compared to those viewing more complex 3D layouts. Higher spatial predispositions can be translated to greater ease in creating a mental representation of space, reducing fixation time, and affecting further eye movement activity (Snopková et al., 2019). Conversely, novice users with low spatial orientation tend to favor more complex and realistic 3D designs (Smallman & Hegarty, 2007; Zheng & Hsu, 2021; Zanola et al., 2009). These designs mimic the familiar environment, providing more context to the property but prolonging fixation time and exhausting cognitive bandwidth.

The chosen literature examples support the following hypothesis:

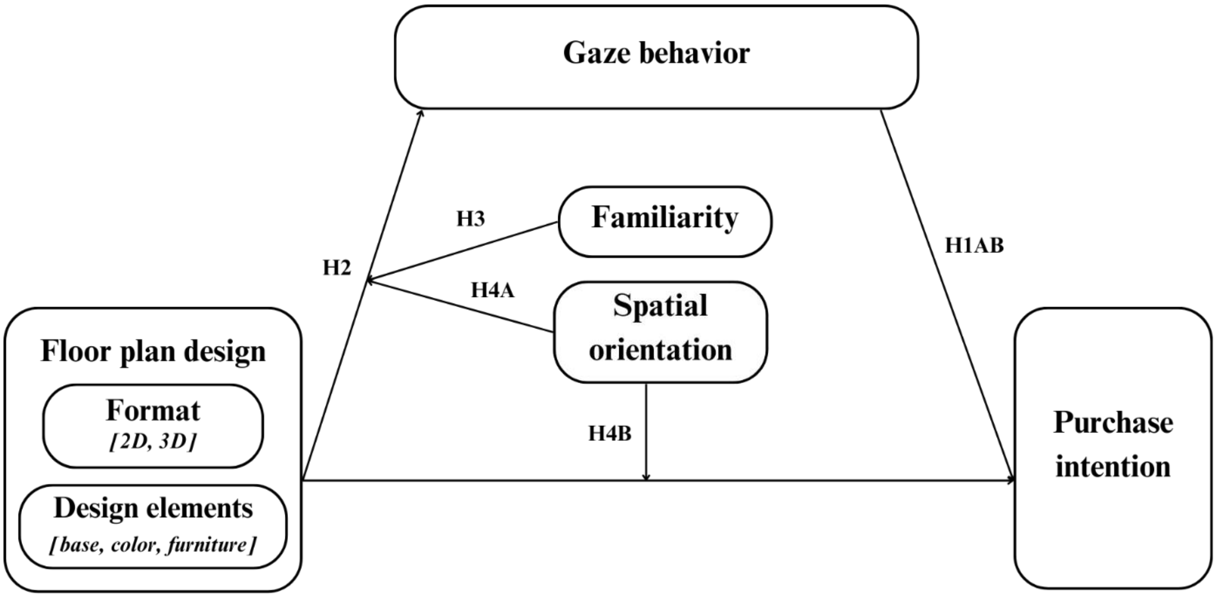
H4A: The number of fixation points and saccades, as well as fixations and viewing duration, will be higher for individuals with low spatial orientation than for those with high spatial orientation.

H4B: Purchase intention scores will be higher for individuals with low spatial orientation when presented with 3D floor plans compared to 2D layouts.

A path diagram was drawn based on all presented earlier hypotheses as follows:

Figure 1

Investigation variables model.



2. Methods

To analyze potential buyers' gaze behavior and preferences toward floor plan types, the investigation employed a 2x3 experimental design with eye-tracking glasses and a questionnaire, focused on evaluating the effect of floor plan design formats (2D and 3D) and elements (base, color and furniture) on gaze behavior (viewing duration, fixation duration, number of fixations and number of saccades) in facilitating property purchase intentions. The role of moderating variables – familiarity with floor plans and spatial orientation in 2D and 3D was examined. Additionally, the study assessed the alignment of design intention and perceptions on the dimensions of complexity, coherence and legibility.

2.1 Equipment and experiment setting

To track the gaze behavior of participants, Tobii Pro 3 Glasses were utilized. The experimental setup included two computers: one operated by the researcher to supervise the eye-tracking recording, and the second used by the participant to fill out a survey and view the floor plan (see Figure 2).

Figure 2

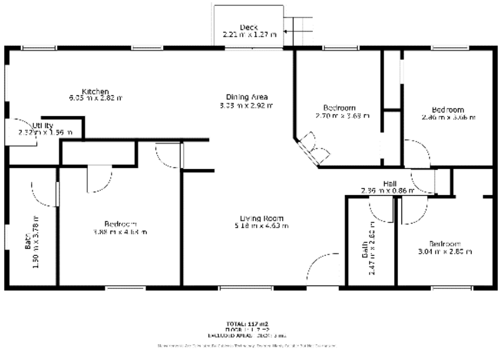
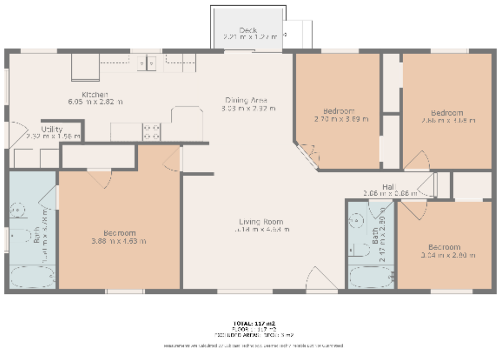
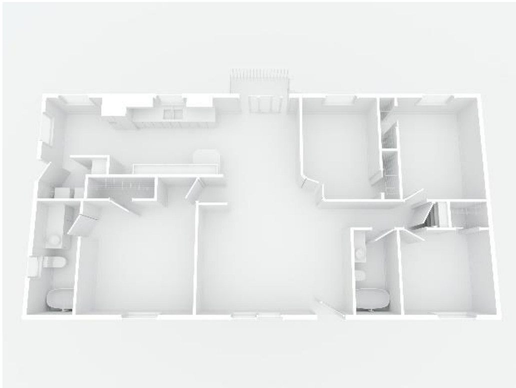
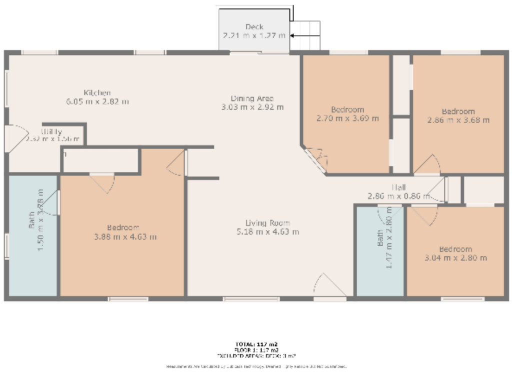
The experimental setup.

2.2 Materials

The floor plans selected for the study were based on a medium-sized U.S. residence, considered representative of an average property layout. These floor plans depicted a one-floor single-family apartment comprising four bedrooms, two baths, a kitchen, an open dining room, and a living room. In total, the study investigated participants' perceptions and purchase intention evoked by six design versions of the same property layout: base, ones with colors and texture, and the ones with fixed furniture, each type duplicated in 2D and 3D (see Figure 3). Depending on the participant's nationality and preference, the displayed 2D floor plan labels were written either in English or Dutch.

Figure 3

Floor plans used within the study.

Design elements	Format	
	2D	**3D**
Base		
Color		
Furniture		

2.3 Procedure

Participants were recruited using a convenience sampling strategy from among students and employees of the University of Twente, as well as regular citizens of Enschede in the Netherlands. During the recruitment procedure, the participants were assigned to the testing condition (floor plan design type) by the researcher to ensure an equal gender group distribution in each group. As the study focused on evaluating both experienced and inexperienced homebuyers, no exclusion criteria regarding past experience were implemented in the screening process. The experiment took place in settings familiar to participants – the Enschede public library and the University of Twente campus. Each participant was tested in a similar controlled environment, in a room separated from external disturbances.

Before participating, individuals were given a consent form informing them about the aim of the study and their right to withdraw their data at any time during and after the experiment. They were instructed to take on the role of a homebuyer in search of a house that meets their requirements. Participants were asked to focus on and evaluate the design part of the property layout. After putting on the eye-tracking equipment and being reminded to remain at an equal distance from the computer screen at all times during the study, participants were asked to start the questionnaire (Appendix A). They were randomly assigned to one of the six conditions, with floor plan labels adjusted based on their language preferences (Dutch or English). Each participant viewed only one floor plan picture to accurately assess participants' perception of the complexity, coherence, and legibility of the floor plan design and to avoid introducing the learning curve effect described by Dadi et al. (2014), which could disturb gaze behavior.

2.4 Participants

The studied population sample consisted of prospective homebuyers above the age of 18. Participants were primarily recruited from the University of Twente in Enschede, Netherlands, resulting in a convenience sample. Fluency in English was a requirement for participation.

In total, 182 people participated in the study, comprising 91 females and 91 males. However, due to technical issues with the eye-tracking equipment, two participants were excluded, resulting in a final sample size of 180 participants, with 90 females and 90 males. The sample had a mean age of $M = 23.74$ (range 18-59). Dutch participants constituted 47.2% ($n = 85$) of the sample, with 17.2% ($n = 31$) being German and 35.6% ($n = 64$) from other countries. The questionnaire revealed that 122 participants (67.8%) encountered the floor plan during their last experience with house/room search, and 142 of the study group (78.9%) had previous experience with in-game navigation. Participants were randomly assigned to view one of the six floor plans used in the experiment (See Table 1 for details), with 30 participants per testing condition. Statistical analysis using the Kruskal-Wallis test revealed no significant demographic differences across the six testing groups (Gender: $\chi^2 = 0.313$, df = 5, $p = 0.99$; Age: $\chi^2 = 6.861$, df = 5, $p = 0.23$; Nationality: $\chi^2 = 3.30$, df = 5, $p = 0.65$).

Table 1
Distribution of the participants and the demographics per condition.

Demographic	2D			3D		
	Base	Color	Furniture	Base	Color	Furniture
Gender						
Female	15	15	15	15	15	15
Male	15	15	15	15	15	15
Age *M*	23.53	24.3	23.4	23.73	24.77	22.7
(*SD*)	(5.70)	(5.23)	(3.86)	(7.23)	(6.40)	(3.79)
Nationality						
Dutch	18	12	13	13	16	13
German	3	10	3	5	5	5
Other	9	8	14	12	9	12

Note. N=180 (n= 30 for each condition)

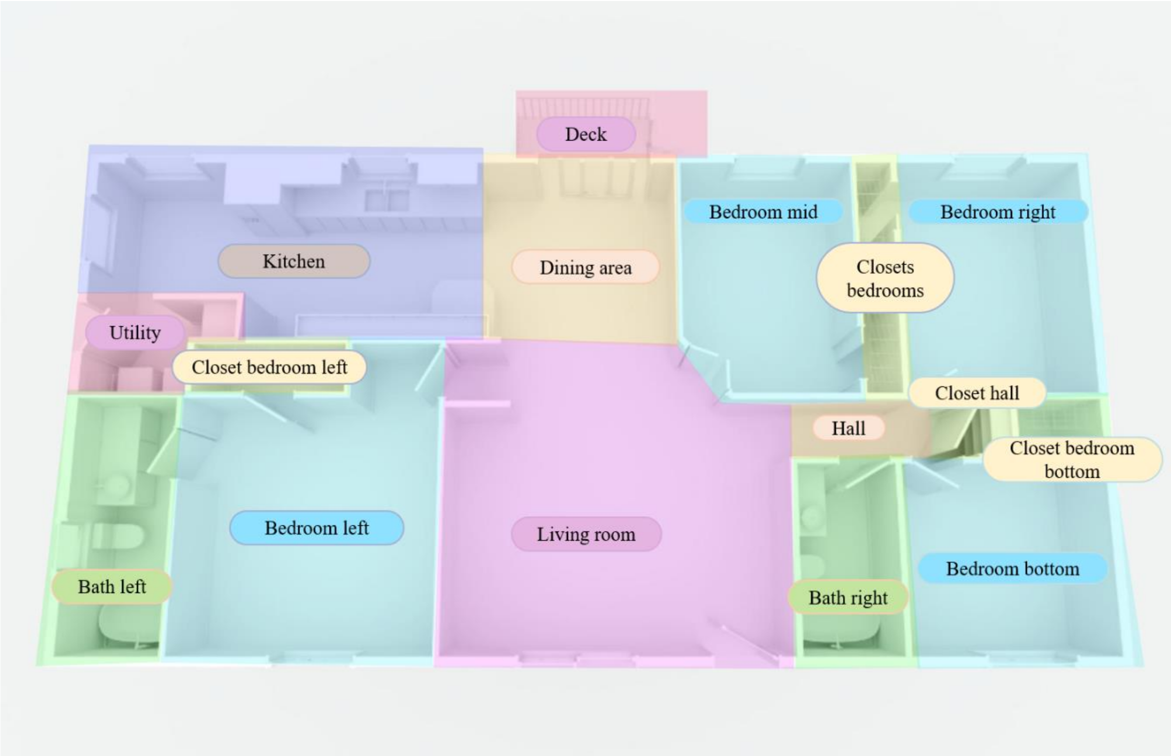
2.5 Measures

2.5.1 Eye-tracking

To discern which floor plan elements, such as walls, doors, furniture, and labels, held particular interest for potential homebuyers, heatmaps and scan path visualizations were generated based on the eye-tracking device recordings. Additionally, the gaze behavior was quantified using metrics such as total viewing duration, total fixation duration, total number of saccades, and total number of fixations. Each floor plan was segmented into multiple Areas of Interest (AOIs), representing different rooms or areas of the property (see Figure 4). Within each AOI, the total duration of visit, duration of fixations, number of saccades, and number of fixations were calculated separately. Furthermore, the most prevalent last viewed AOIs were identified for each floor plan type.

Figure 4

Floor plan's Areas of Interest



2.5.2 Perceived complexity

To assess the perceived complexity of the presented floor plans the researcher has adapted the guidance questions from the study of Kuper (2017). First participants were asked to rate the complexity of the property layout on a 5-point Likert scale from *not complex at all* to *very complex*. This score was then combined with a further four-item questionnaire, that included statements such as "The floor plan is densely packed with information" and "There floor plan displayed elements of different kinds". Responses were recorded on a 5-point Likert scale ranged from *strongly disagree* to *strongly agree*. Combined 5-item scale had acceptable internal consistency ($\alpha = 0.78$).

2.5.3 Perceived coherence

To assess the perceived coherence of the presented floor plans the researcher has adapted the guidance questions from the study of Kuper (2017). First participants were asked to rate the coherence of the property layout on a 5-point Likert scale from *not coherent at all* to *very coherent*. This score was then combined with a further four-item questionnaire, that included statements such as "The structure of the scene was logical" and "The layout was clear and organized”. Responses were recorded on a 5-point Likert scale ranged from *strongly disagree* to *strongly agree*. Combined 5-item scale had good internal consistency (α = 0.86).

2.5.4 Perceived legibility

To assess the perceived legibility of the presented floor plans the self-composed questionnaire was utilized. First participants were asked to rate the legibility of the property layout on a 5-point Likert scale from *not legible at all* to *very legible*. This score was then combined with a further four-item questionnaire, that included statements such as “It was easy for me to mentally navigate through the layout” and “I can quickly find important information such as rooms key features in this floor plan”. Responses were recorded on a 5-point Likert scale ranged from *strongly disagree* to *strongly agree*. Combined 5-item scale had good internal consistency (α = 0.85).

2.5.5 Familiarity with floor plan

To assess participants’ potential familiarity with a floor plan through the home searching process a question “Think of the last time you were searching for a property to buy or rent, or a room to rent. During that search, did you look at the floor plan (layout) of the property?” was asked. Responses were recorded on a *Yes/No/Not sure* basis.

To assess participants’ potential familiarity with a floor plan through the experience with reading maps while gaming a question “Do you have experience playing video games that involve map navigation, such as navigating through landmarks or buildings?” was asked. Responses were recorded on a *Yes/No* basis.

The responses were recoded into a single familiarity dummy variable, with a value of 0 corresponding to no experience with floor plans in any form, and a value of 1 indicating familiarity acquired through the house searching process, in-game maps, or both.

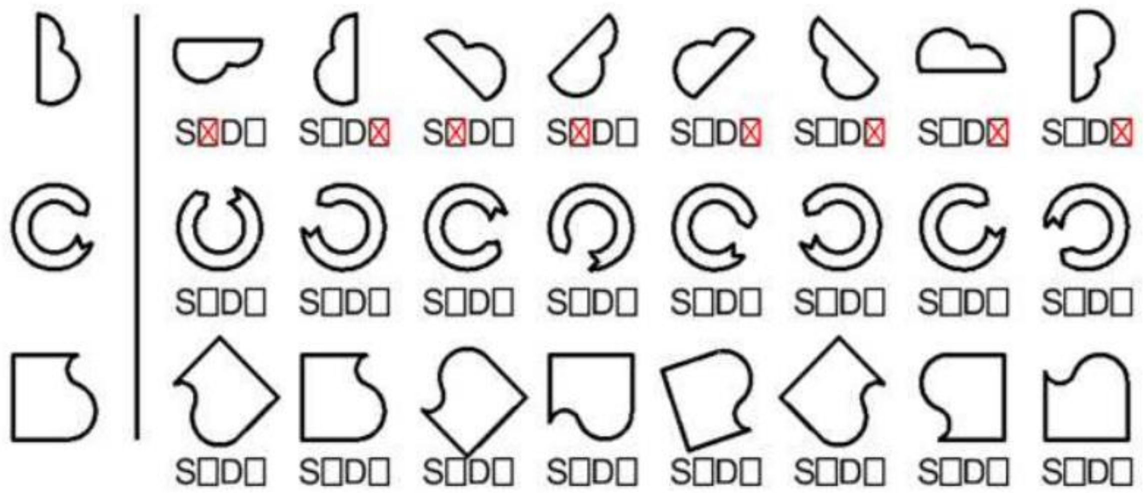
2.5.6 Spatial orientation

To assess participants’ spatial orientation, an existing Card Rotation and Cube Comparison tests were adapted from The Educational Testing Service (Ekstrom et al., 1976, as cited in Goodrum et al., 2016). In the card rotation test each question illustrated a 2D shape and eight similar objects. Participants must determine whether each object has been rotated – corresponding to answer *same*, or flipped – answer *different* (see Figure 5a). Similarly, the cube comparison test depicted two cubes marked with a letter on each side. Given that a single cube cannot display two of the same letters, the participant again had to determine if the second cube has been turned into a different position (answer *same*) or is the position of the letters incorrect (answer *different*; see Figure 5b). The number of correctly marked objects determined a participant's score on respectively two-dimensional and three-dimensional object manipulation.

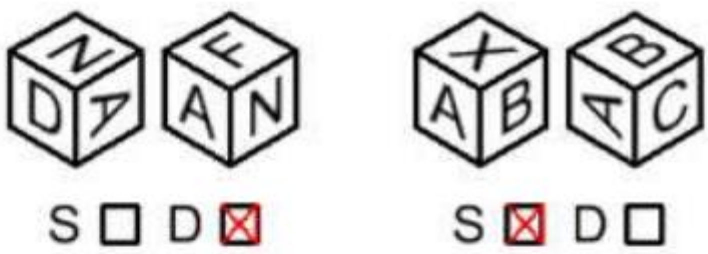
Figure 5

Spatial relations orientation question examples from a) card rotation test, b) cube comparison test.

a)



b)



2.5.7 Purchase intention

To assess the participants' intention to purchase the viewed property a question "Based just on the visual aspects of the floor plan you have just viewed during your house search, how likely are you to consider buying this property?" was asked. Responses were recorded on a 5-point Likert scale ranged from *extremely unlikely* to *extremely likely*.

2.6 Data analysis

First, participants' gaze behavior, recorded with the Tobii Pro 3 Glasses, was mapped onto the respective floor plans using automated image recognition in Tobii Pro Lab software.

Recordings of poor quality, including shaky footage or instances where automatic mapping failed to recognize the floor plan, were manually mapped. Since the materials used were part of a single survey, standardized criteria were established to determine the start and finish of the floor plan interpretation process by the participant. The start of the mapped interval was marked by the participant clicking to enlarge the image, and it ended when they chose to click the close button on the survey page. The data were initially mapped raw and then aggregated with the fixation level filter, which allowed for the removal of outliers and missing eye-tracking data. Selected gaze metrics were extracted and combined with the questionnaire answers for further analysis.

To assess the validity of the materials, quantitative methods were applied. Firstly, the means and standard deviations for the questionnaire independent variables were generated (see Table 2). The Kruskal-Wallis test revealed significant differences across the six testing groups with regards to participants perception of complexity, $\chi^2 = 41.74$, df = 5, $p < .001$; coherence: $\chi^2 = 11.58$, df = 5, $p = 0.041$; and legibility: $\chi^2 = 13.26$, df = 5, $p = 0.021$).

For further analysis, the spatial orientation scores were categorized to distinguish individuals in the population sample with low and high scores. Latent Profile Analysis (LPA) was conducted separately for 2D and 3D spatial orientation scores, resulting in three distinct groups for 2D scores (*low*, *medium*, *high*) and two groups for 3D scores (*low*, *high*). The 3-profile solution for 2D scores was supported by the lowest BIC (BIC = -1260) and high entropy (0.85), while the 2-profile solution for 3D scores was supported by the lowest BIC (BIC = -1035) and high entropy (0.88). The Kruskal-Wallis test revealed no statistically significant differences in the spatial orientation scores in 2D and 3D and the respective spatial orientation subgroups among the six testing conditions (p >0.05). Most of the studied population sample had above-average scores of the spatial orientation, with 101 people for 2D and 103 for 3D.

The descriptive statistics indicated potential violations of assumptions necessary for ANOVA and linear regression analyses. Specifically, the standard deviation exceeded the mean for some of the gaze metrics, suggesting high skewness or heavy-tailed distributions. To verify these concerns, an Anderson-Darling test for normality was carried out. The Anderson-Darling test results revealed significant deviations from normality for viewing duration, duration of fixations, number of fixations, and number of saccades (*p's* < 0.01). To obtain a normal distribution the gaze behavior data were Cube Root transformed. The overview of means and standard deviations before and after the Cube Root transformation is presented in Table 3.

Table 2

Means (and standard deviations) of questionnaire variables as a function of floor plan design (2D or 3D) and design elements (base, color or furniture).

Variable	2D								3D								**Total**	
	Base		Color		Furniture		**Total**		Base		Color		Furniture		**Total**			
	n	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)
Complexity	30	2.65 (0.71)	30	3.2 (0.61)	30	3.2 (0.79)	**90**	**3.03 (0.75)**	30	3.4 (0.66)	30	3.44 (0.83)	30	3.99 (0.81)	**90**	**3.6 (0.81)**	**180**	**3.32 (0.83)**
Coherence	30	3.79 (0.87)	30	4.07 (0.80)	30	3.85 (0.92)	**90**	**3.84 (0.86)**	30	4.27 (0.47)	30	4.18 (0.67)	30	3.77 (1.17)	**90**	**4.13 (0.86)**	**180**	**4.02 (0.87)**
Legibility	30	3.9 (0.82)	30	4.29 (0.61)	30	4.23 (0.70)	**90**	**4.14 (0.73)**	30	4.36 (0.70)	30	4.13 (0.72)	30	3.59 (1.12)	**90**	**4.03 (0.92)**	**180**	**4.08 (0.83)**
Spatial orientation 2D	30	30.43 (8.98)	30	31.60 (8.51)	30	27.20 (13.26)	**90**	**29.74 (10.52)**	30	31.70 (6.68)	30	33.27 (6.43)	30	28.5 (9.51)	**90**	**31.16 (7.84)**	**180**	**30.42 (9.28)**
Low	5	13.8 (5.02)	3	11.67 (4.51)	6	5.17 (12.04)	**14**	**9.64 (9.14)**	3	18.33 (1.53)	2	18.00 (2.83)	5	11.60 (6.27)	**10**	**14.90 (5.57)**	**24**	**11.83 (8.14)**

Medium	17	31.41 (4.12)	18	30.89 (4.11)	16	29.81 (4.64)	**51**	**30.73 (4.21)**	19	30.63 (3.83)	17	31.18 (3.91)	17	28.75 (3.80)	**53**	**30.21 (3.91)**	**104**	**30.46 (4.05)**
High	8	38.75 (1.39)	9	39.67 (0.71)	8	38.50 (1.07)	**25**	**39.00 (1.15)**	8	39.25 (1.16)	11	39.27 (1.01)	8	38.50 (1.07)	**27**	**39.04 (1.09)**	**52**	**39.02 (1.11)**
Spatial orientation 3D	30	8.20 (3.50)	30	7.70 (4.62)	30	6.10 (4.94)	**90**	**7.33 (4.44)**	30	7.90 (3.92)	30	8.17 (4.43)	30	7.87 (3.74)	**30**	**7.98 (4.00)**	**180**	**7.67 (4.23)**
Low	4	2.75 (1.50)	9	1.78 (2.49)	9	-0.34 (2.87)	**22**	**1.09 (2.72)**	5	1.00 (2.24)	8	2.25 (2.25)	6	2.17 (1.60)	**19**	**1.89 (2.02)**	**41**	**1.46 (2.43)**
High	26	9.04 (2.90)	21	10.24 (2.43)	21	8.86 (2.35)	**68**	**9.35 (2.63)**	25	9.28 (2.41)	22	10.32 (2.70)	24	9.29 (2.54)	**71**	**9.61 (2.55)**	**139**	**9.48 (2.59)**

Table 3

Means (and standard deviations) of gaze behavior metrics before and after Cube Root-transformation

Variable	Before the transformation			After the transformation		
	M (*SD*)	Skewness	Kurtosis	*M* (*SD*)	Skewness	Kurtosis
Viewing duration	59.32 (33.11)	2.10	10.48	3.79 (0.66)	0.40	4.33
Fixations duration	46.09 (25.45)	1.69	8.29	3.47 (0.63)	0.14	3.72
Number of fixations	124.07 (67.22)	2.45	15.31	4.85 (0.83)	0.28	4.70
Number of saccades	111.02 (61.69)	2.42	15.66	4.66 (0.82)	0.31	4.39

Cleaned data were checked for outliers, and then fitted to ANOVA and linear regression models. First, two-way ANOVAs considered the effect of the design format (2D and 3D) and design elements (base, color, and with furniture) on gaze behavior metrics and the dependent variable – purchase intention. Next, following the Baron and Kenny (1986) methodology, the analysis of linear regressions checked if the relationship between the independent variables – format and design elements and dependent variable – purchase intention, can be explained by a mediator variable – gaze behavior. Further analysis examined the moderating effect of familiarity with floor plans and spatial orientation in 2D and 3D. Relevant ANOVA and linear regression tests were complemented by non-parametric tests to confirm the findings. The summary of the results is presented in the following section of the report.

3. Results

The following section outlines the results of data analysis. First the heatmaps representing the viewing patterns of population sample were evaluated. Secondly, the main relationships between floor plan format, design elements, gaze behavior and purchase intention were analyzed with two-way ANOVAs and linear regressions. Furthermore, the effects of moderators – familiarity with the floor plans and spatial orientation in 2D and 3D were evaluated. Last section contains the overview of the confirmation or rejection of the tested hypotheses.

3.1 Gaze visualization

The visualization of participants' relative fixation count on each respective floor plan design type can be seen in Figure 6. In the 2D format, the room labels and dimensions drew the most attention from the participants, with connecting points of the rooms being of secondary importance. Conversely, the base and colored 3D floor plans directed viewers' gaze towards the closets, room entries, and fixtures. The 3D floor plan with proposed furnishing primarily directed participants' gaze to the center of each respective space, evoking a much more clustered together fixation range. Overall, the living room was the most often viewed area, and participants most often ended their viewing of the floor plan on it.

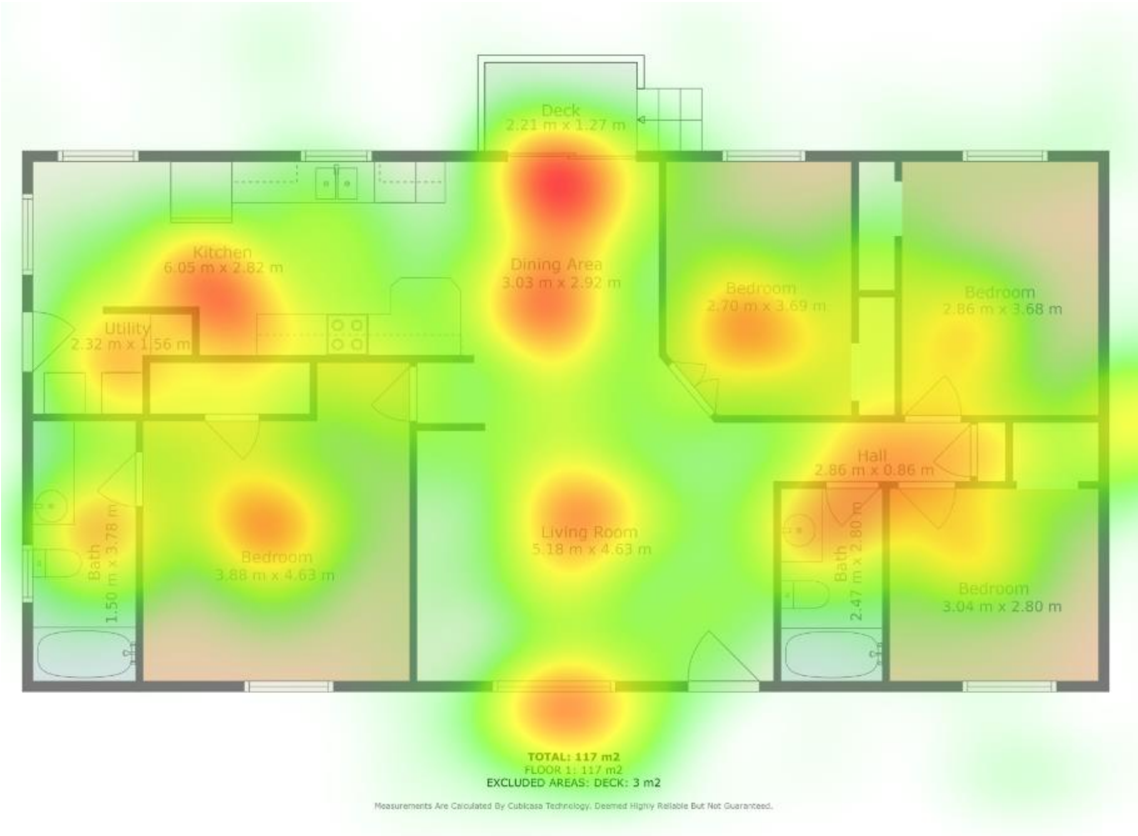
Figure 6

Heat map visualization of participants relative fixations count per floor plan format and design elements.

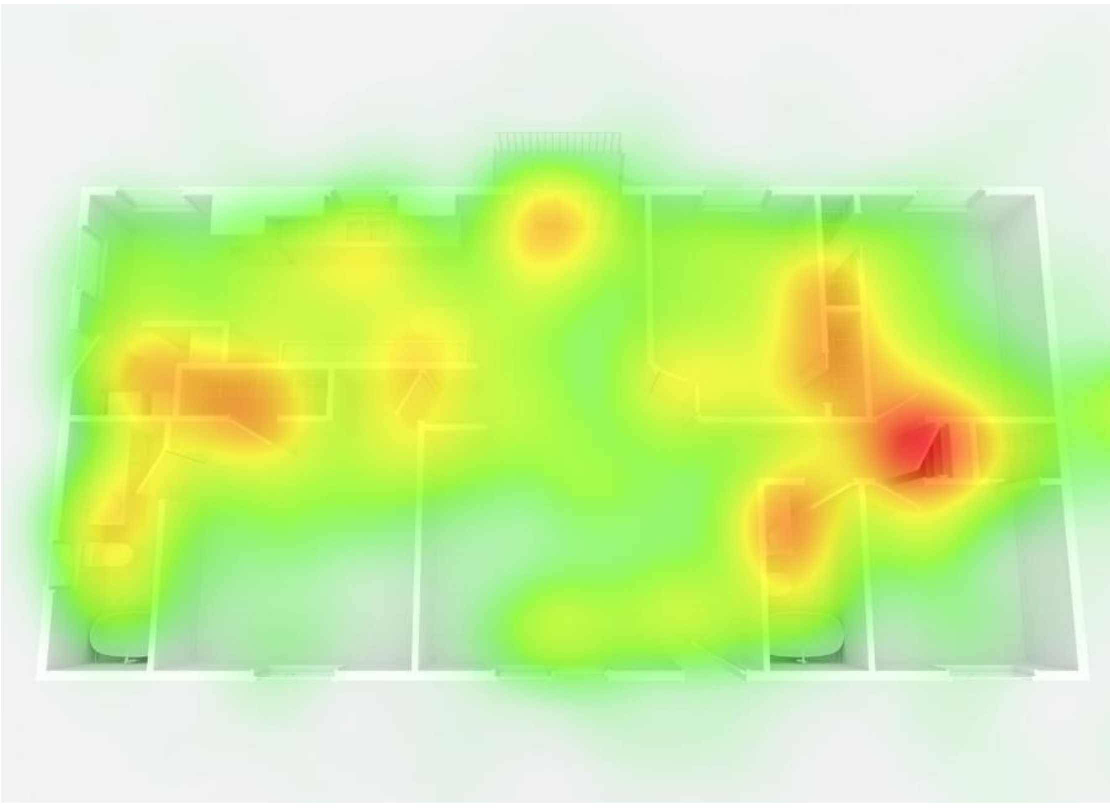
a) 2D Base

b) 2D Color

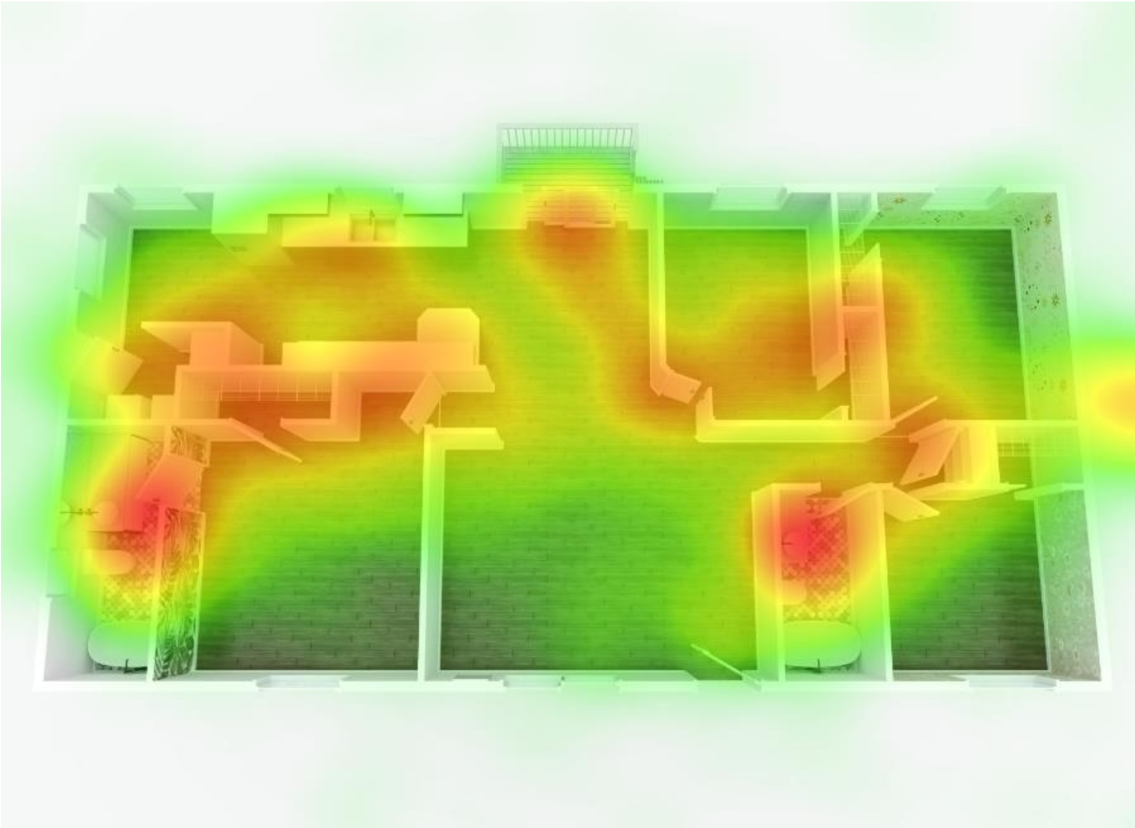
c) 2D Furniture



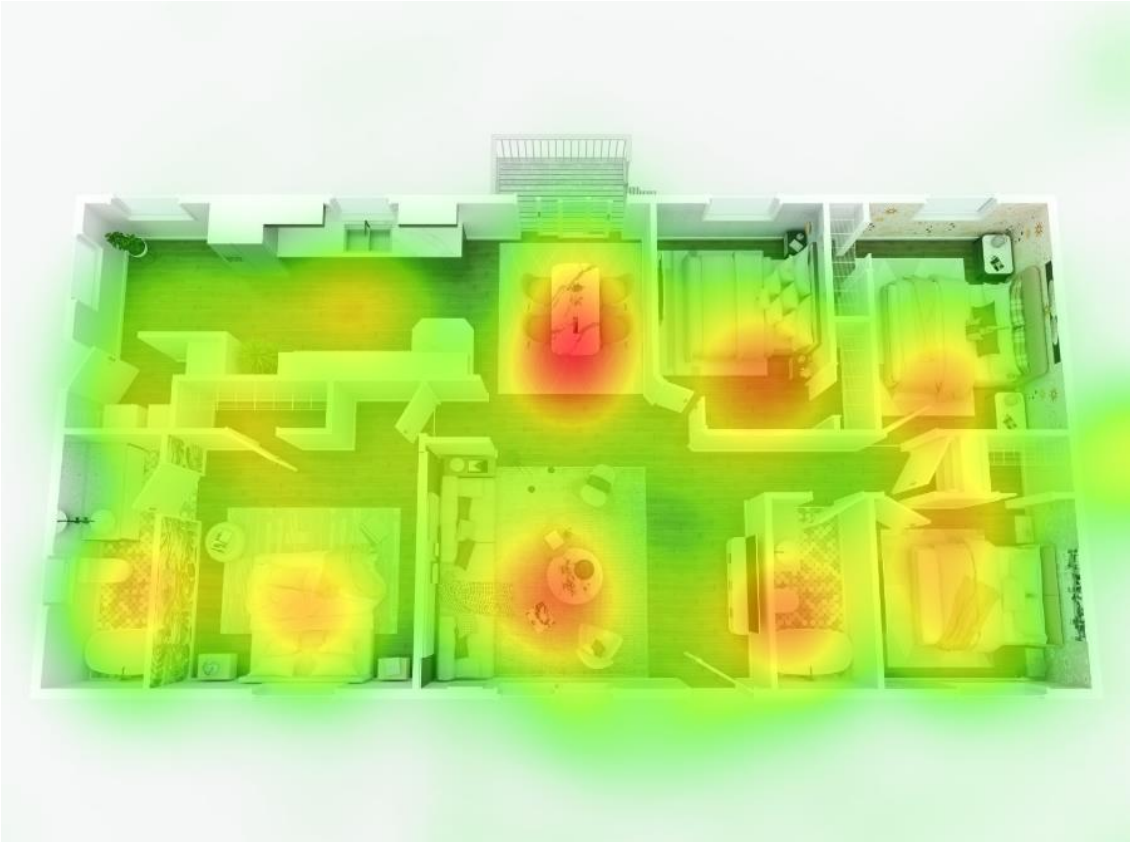
d) 3D Base



e) 3D Color



f) 3D Furniture



3.2 Main variables effects

3.2.1 The effect of the format and design elements on gaze behavior.

A two-way ANOVA analyses were conducted to determine the effect of the format and design elements of the floor plans on the eye behavior metrics –viewing duration, fixations duration, number of fixations, number of saccades respectively. The results of each respective analysis are summarized in Table 4.

Table 4

A two-way ANOVAs results for floor plan format and design elements effect on gaze behavior.

Dependent Variable	Predictor	*SS*	*Df*	*MS*	*F*	*p*
Viewing Duration	Format	3.58	1	3.58	8.61	.004
	Design elements	0.33	2	0.163	0.39	.676
	Format x Design elements	2.37	2	1.18	2.85	.061
	Error	72.33	174	0.416		
Fixations Duration	Format	2.37	1	2.37	6.22	.014

	Design elements	0.36	2	0.18	0.47	.625
	Format x Design elements	2.48	2	1.24	3.25	.041
	Error	66.36	174	0.38		
Number of Fixations	Format	4.42	1	4.42	6.88	.009
	Design elements	2.02	2	1.01	1.57	.211
	Format x Design elements	4.96	2	2.48	3.86	.023
	Error	111.80	174	0.64		
Number of saccades	Format	3.64	1	3.64	5.79	.017
	Design elements	2.31	2	1.16	1.84	.162
	Format x Design elements	4.64	2	2.32	3.69	.027
	Error	109.44	174	0.63		

Note. *SS* = sum of squares; *Df* = degrees of freedom; *MS* = mean square; *F* = F-ratio; *p* = significance level.

The results revealed the statistical significance of the main effect of the format of the floor plans on all gaze metrics (*p's* <0.05). Additionally explored relationship between the floor plan format and design elements proved significant for fixations duration, number of fixations and number of saccades. Also, the Kruskal-Wallis tests were performed to confirm the findings. These tests determined statistically significant differences in gaze behavior between two floor plan formats (*p's* <.001) and no statistically significant differences for the design elements (*p's* >.05) for all gaze metrics. This suggests that participants direct their visual attention differently, dependent on the floor plan format they are viewing and their combination with displayed elements. The 2D format of floor plans is connected to prolonged interpretation process and more dispersed viewing patterns than the 3D one (see Table 5). Within their respective categories, the highest gaze metrics (number of fixations and saccades) were connected to the 2D colored floor plan and the 3D layout with proposed furniture. The base type of floor plan design received a moderate level of visual attention from participants, ranked second in each format group in terms of viewing and fixation duration, and the number of fixations and saccades.

Table 5

Means (and standard deviations) of gaze behavior metrics after cube root transformation as a function of floor plan design (2D or 3D) and design elements (base, color or furniture).

Variable	2D				3D				Total
	Base	Color	Furniture	**Total**	Base	Color	Furniture	**Total**	
Viewing duration [seconds]	3.13 (1.17)	3.57 (0.97)	3.43 (1.10)	**3.38 (1.09)**	4.00 (0.95)	3.87 (0.97)	3.40 (1.19)	**3.76 (1.06)**	**3.79 (0.66)**
Duration of fixations [seconds]	3.47 (0.66)	3.76 (0.74)	3.54 (0.73)	**3.59 (0.71)**	3.36 (0.50)	3.20 (0.59)	3.51 (0.42)	**3.36 (0.52)**	**3.47 (0.63)**
Number of fixations	4.89 (0.74)	5.14 (1.06)	4.99 (0.87)	**5.00 (0.90)**	4.69 (0.73)	4.37 (0.68)	5.01 (0.63)	**4.69 (0.72)**	**4.85 (0.83)**
Number of saccades	4.67 (0.79)	4.96 (1.02)	4.80 (0.88)	**4.81 (0.90)**	4.47 (0.69)	4.25 (0.68)	4.85 (0.62)	**4.52 (0.71)**	4.66 (0.82)

3.2.2 The effect of the format and design elements on the purchase intention

A two-way ANOVA was conducted to examine the effects of floor plan format and design on purchase intention. The results showed a significant main effect of the format of the floor plan, $F(1,174) = 6.42$, $p = .018$, indicating that the format significantly influences purchase intention. The main effect of the design elements was not significant, $F(2,174) = 2.70$, $p = .306$. Additionally explored interaction term between floor plan format and design was also not significant, $F(2,174) = 6.21$, $p = .067$. This suggests that elements displayed on the property visualization do not influence viewer's purchase intention, and that this result holds regardless of which floor plan format the elements were used in.

The purchase intention for the 2D format of floor plans was lower ($M = 3.38$, $SD = 1.09$) than for the 3D format ($M = 3.76$, $SD = 1.06$). This suggests that the population sample was more inclined to consider purchasing the property when viewing the 3D floor plans than when viewing the 2D ones. Consequently, the combination of the 3D format and base design element resulted in the highest purchase intention ($M = 4.00$, $SD = 0.95$), followed by the colored 3D floor plan ($M = 3.87$, $SD = 0.97$). The lowest purchase intention was evoked by the base 2D floor plan (*M* = 3.12, *SD* = 1.17). This suggests that the use of 3D formats, especially with effective design elements (base, color), significantly enhances the appeal and potential purchase intention of the property.

3.2.3 The effect of the gaze metrics on the purchase intentions.

A linear regression was conducted to determine the effect of the gaze metrics – viewing duration, fixations duration, number of fixations, number of saccades on the purchase intention. The results of analysis are summarized in Table 6.

Table 6

Multiple regression results for the effect of gaze metrics on purchase intention

Predictor	*b*	95% CI	*SE*	*t*	*p*
Intercept	3.75	[2.78, 4.71]	0.49	7.66	< .001
Viewing duration [seconds]	-0.17	[-1.46, 1.11]	0.65	-0.26	.794
Fixation durations [seconds]	0.78	[-0.60, 2.17]	0.70	1.11	.267
Number of fixations	0.26	[-0.56, 1.07]	0.41	0.62	.538
Number of saccades	-0.75	[-1.67, 0.18]	0.47	-1.60	.112

Note. *b* = unstandardized coefficient; CI = confidence interval for *b*; *SE* = standard error. R^2 = .025, adjusted R^2 = .003, $F(4, 175) = 1.11$, $p = .35$.

The linear regression found no statistically significant effect of the gaze behavior on purchase intention. This suggests that the way individuals viewed the floor plan does not impact their willingness to purchase the displayed property. A possible explanation of this can be related to the detected multicollinearity of the gaze behavior variables, inflating the standard errors of the coefficients and making it difficult to determine the individual effect of each predictor. The Variance Inflation Factor values ranged from 18.89 for the number of fixations to 30.08 for fixations duration, indicating moderate to severe levels of collinearity among the predictors. This high degree of correlation suggests that these variables may not independently contribute to the prediction of purchase intention.

3.2.4 Mediation effect of gaze behavior

The following section proceeds with the mediation check utilizing linear regressions, as outlined by Baron and Kenny (1986), focusing on the mediating effect of gaze behavior on the relationship between floor plan design and purchase intention. The above-mentioned analyses indicated that the floor plan format was found to significantly influence the purchase intention, and all of the gaze behavior metrics (see *Results* 3.2.1 and 3.2.2). However, the gaze behavior metrics were not found to significantly impact the purchase intention (see *Results* 3.2.3). This lack of the main effect contradicts the assumptions of Baron and Kenny (1986), indicating lack of the mediating effect of the gaze behavior on the relationship between floor plan format and purchase intention.

3.3 Moderators effects on gaze behavior

3.3.1 The moderating effect of familiarity on the relationship between format and design of the floor plan and gaze behavior.

The following two-way ANOVAs were carried out to investigate the main and moderating effect of the familiarity with floor plans and in-game maps on the relation between format and design of the floor plans and gaze behavior. The results of each respective analysis are summarized in Table 8. The two-way ANOVAs confirmed the statistical significance of the main effect of the format of the floor plans on the gaze metrics. All remaining independent variables, including the familiarity with floor plans proved insignificant. This suggests that differing familiarity levels with floor plans obtained either via previous house search or the in-game maps does not change the way individuals view the property layout.

Table 8

A two-way ANOVAs results for floor plan format and design elements effect and the moderation effect of familiarity on gaze metrics.

Dependent Variable	Predictor	*SS*	*Df*	*MS*	*F*	*p*
Viewing Duration	Format	3.58	1	3.58	8.30	.005
	Design elements	0.33	2	0.16	0.38	.659
	Familiarity	0.02	1	0.02	0.06	0.812
	Format x Familiarity	0.26	1	0.26	0.61	.436
	Design x Familiarity	0.22	1	0.11	0.26	.773
	Error	74.18	172	0.43		
Fixations Duration	Format	2.37	1	2.37	5.97	.016
	Design elements	0.36	2	0.18	0.45	.637
	Familiarity	0.00	1	0.00	0.00	.993
	Format x Familiarity	0.46	1	0.46	1.16	.283
	Design x Familiarity	0.04	2	0.02	0.055	.946
	Error	68.34	172	0.40		
Number of Fixations	Format	4.42	1	4.42	6.61	.011
	Design elements	2.02	2	1.01	1.51	.224
	Familiarity	0.49	1	0.49	0.73	.395
	Format x Familiarity	1.18	1	1.18	1.77	.185
	Design x Familiarity	0.08	2	0.04	0.06	.941
	Error	115.01	172	0.669		
Number of saccades	Format	3.64	1	3.64	5.68	.019
	Design elements	2.31	2	1.16	1.77	.276
	Familiarity	0.13	1	0.13	0.19	.604
	Format x Familiarity	1.24	1	1.24	1.89	.245
	Design x Familiarity	0.30	2	0.15	0.23	.797
	Error	112.41	172	0.65		

Note. *SS* = sum of squares; *Df* = degrees of freedom; *MS* = mean square; *F* = F-ratio; *p* = significance level.

3.3.2 The moderating effect of spatial orientation in 2D and 3D on the relationship between format and design of the floor plan and gaze behavior.

The following two-way ANOVAs were carried out to investigate the main and moderating effect of the 2D and 3D spatial orientation on the relationship between format, design of the floor plans, and gaze behavior. The results of each respective analysis are summarized in Table 9.

Table 9

A two-way ANOVAs results for floor plan format and design elements effect and the moderation effect of spatial orientation in 2D and 3D on gaze metrics.

Dependent Variable	Predictor	*SS*	*Df*	*MS*	*F*	*p*
Viewing Duration	Format	3.58	1	3.58	8.78	.003
	Design elements	0.33	2	0.16	0.40	.671
	Spatial Orientation 2D	0.96	2	0.48	1.17	.312
	Spatial Orientation 3D	0.03	1	0.03	0.06	.803
	Format x Spatial Orientation 2D	0.66	2	0.33	0.81	.445
	Design x Spatial Orientation 2D	2.00	4	0.50	1.23	.302
	Format x Spatial Orientation 3D	0.11	1	0.11	0.26	.608
	Design x Spatial Orientation 3D	4.09	2	2.04	5.01	.008
	Error	66.86	164	0.41		
Fixations Duration	Format	2.37	1	2.37	6.24	.014
	Design elements	0.36	2	0.18	0.47	.63625
	Spatial Orientation 2D	1.06	2	0.53	1.40	.25250
	Spatial Orientation 3D	0.01	1	0.01	0.02	.892
	Format x Spatial Orientation 2D	0.62	2	0.31	0.82	.442
	Design x Spatial Orientation 2D	1.47	4	0.37	0.96	.423
	Format x Spatial Orientation 3D	0.29	1	0.29	0.76	.386
	Design x Spatial Orientation 3D	3.00	2	1.50	3.95	.021
	Error	62.39	164	0.38		
Number of Fixations	Format	4.42	1	4.42	6.75	.010
	Design elements	2.02	2	1.01	1.54	.2171
	Spatial Orientation 2D	0.73	2	0.36	0.56	.574
	Spatial Orientation 3D	0.00	1	0.00	0.00	.957

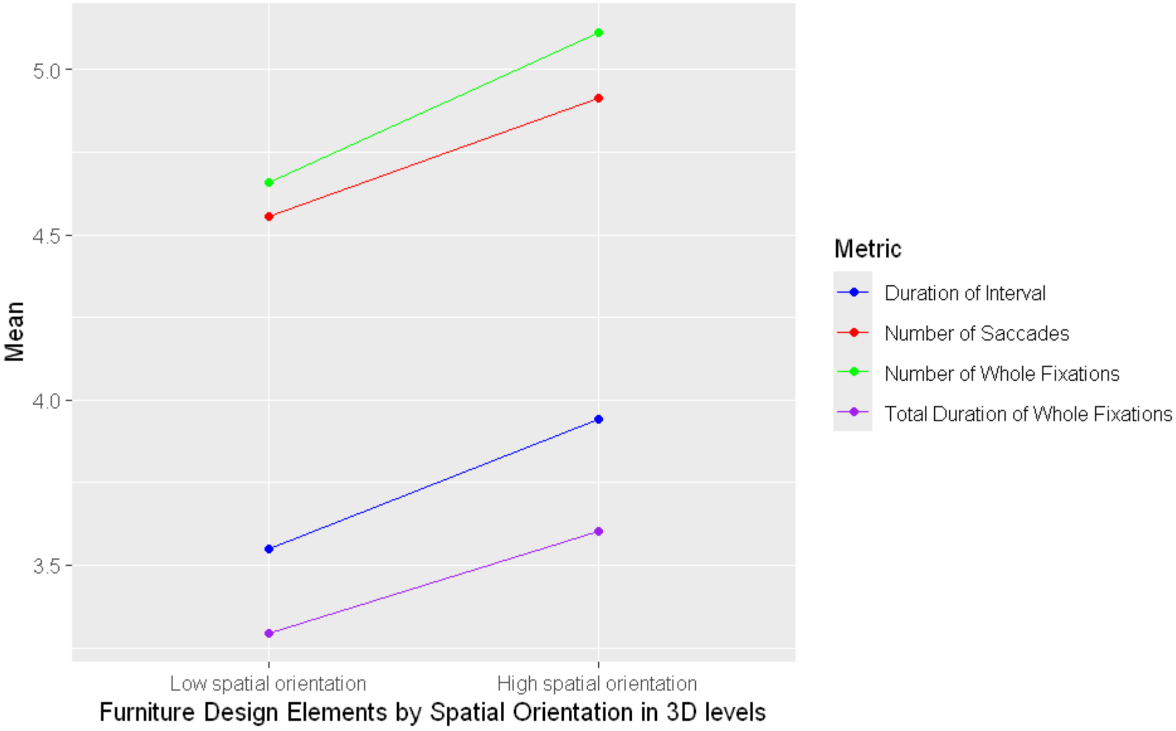
	Format x Spatial Orientation 2D	0.39	2	0.20	0.30	.742
	Design x Spatial Orientation 2D	3.04	4	0.76	1.16	.331
	Format x Spatial Orientation 3D	0.07	1	0.07	0.11	.734
	Design x Spatial Orientation 3D	5.12	2	2.56	3.91	.022
	Error	107.41	164	0.66		
Number of saccades	Format	3.64	1	3.65	5.67	.018
	Design elements	2.31	2	1.15	1.80	.169
	Spatial Orientation 2D	1.31	2	0.65	1.02	.364
	Spatial Orientation 3D	0.02	1	0.02	0.03	.872
	Format x Spatial Orientation 2D	0.61	2	0.30	0.47	.624
	Design x Spatial Orientation 2D	2.43	4	0.61	0.95	.438
	Format x Spatial Orientation 3D	0.12	1	0.12	0.19	.665
	Design x Spatial Orientation 3D	4.20	2	2.10	3.27	.041
	Error	105.39	164	0.64		

Note. *SS* = sum of squares; *Df* = degrees of freedom; *MS* = mean square; *F* = F-ratio; *p* = significance level.

The results confirmed the statistical significance of the main effect of the format of the floor plans on the gaze metrics. Additionally, the moderating effect between the design elements and different levels of spatial orientation in 3D proved significant for all gaze metric (see Figure 8). All remaining independent variables main and moderating effects proved insignificant. Given the violation of normality assumptions of the gaze metrics, the Kruskal-Wallis tests were performed to confirm the findings. These tests determined statistically significant differences in gaze behavior between people with low and high 3D spatial orientation viewing the floor plan with furniture, $\chi 2$ (1) = 4.67, $p = 0.031$, and no statistically significant differences for the remaining design elements, independent variables and gaze metrics (p's > 0.05).

Figure 8

Means plot of gaze metrics for floor plan with furniture design element by low and high spatial orientation in 3D.



Those results suggests that people with low spatial orientation in 3D viewed the floor plans with furniture much quicker (as indicated by the viewing duration and fixations duration) and in less scattered way (as indicated by number of saccades) than people with high spatial orientation in 3D. Conversely, the 2D spatial orientation skills do not play a role in gaze behavior when viewing floor plans. The summary of the means and standard deviations of spatial orientation in 3D for each floor plan design element is presented in Table 2 in the *Methods* section.

3.4 Moderators effects on purchase intention

3.4.1 The moderating effect of spatial orientation on the relationship between format, design elements and purchase intention.

The following two-way ANOVAs were carried out to investigate the main and moderating effect of the 2D and 3D spatial orientation on the relationship between format, design of the floor plans, and purchase intention. The results of analysis are summarized in Table 10.

Table 10

A two-way ANOVA results for floor plan format and design elements effect and the moderation effect of spatial orientation in 2D and 3D on purchase intention.

Dependent Variable	Predictor	*SS*	*Df*	*MS*	*F*	*p*
Purchase intention	Format	6.42	1	6.42	5.69	.018
	Design elements	2.70	2	1.35	1.20	.305
	Spatial Orientation 2D	1.90	2	0.95	0.84	.433
	Spatial Orientation 3D	2.62	1	2.62	2.32	.130
	Format x Spatial Orientation 2D	4.53	2	2.26	2.00	.138
	Design x Spatial Orientation 2D	3.96	4	0.99	0.88	.480
	Format x Spatial Orientation 3D	0.31	1	0.31	0.28	.600
	Design x Spatial Orientation 3D	4.51	2	2.25	2.00	.139
	Error	185.24	164	1.13		

Note. *SS* = sum of squares; *Df* = degrees of freedom; *MS* = mean square; *F* = F-ratio; *p* = significance level.

The results of the two-way ANOVA confirmed the statistical significance of the main effect of the format of the floor plans on the gaze metrics. All remaining independent variables main and moderating effects proved insignificant. This suggests that spatial orientation in 2D and 3D does not influence the purchase intention when the individual is viewing certain type of floor plan.

3.6 Overview of hypotheses

The summary of the results organized per hypothesis are presented in the Table 10.

Table 10

Hypotheses confirmation overview

Hypothesis	Result	Most interesting findings
H1A: Gaze behavior will have a mediating effect on the relationship between floor plan format (2D, 3D), design elements (base, color, furniture) and property purchase intention.	Rejected	The number of saccades loses statistical significance for purchase intention when added to the model with floor plan format.
H1B: Gaze behavior (prolonged floor plan viewing duration) will have a positive effect on property purchase intention.	Rejected	The viewing duration is not statistically significant for purchase intention. However, the number of saccades proved to have a significant effect on the purchase intention.
H2: Gaze behavior (the number of fixation points and saccades as well as fixations and viewing duration) will be lower for 2D than for 3D floor plan design viewers.	Rejected	The gaze behavior metrics were higher for the 2D format group.
H3: Individuals familiar with reading floor plans or in-game maps will have fewer fixation points and saccades and shorter viewing and fixation durations than inexperienced individuals.	Rejected	Familiarity with floor plans didn't have statistically significant effect on the gaze behavior.
H4A: The number of fixation points and saccades, as well as fixations and viewing duration, will be higher for individuals with low spatial orientation than for those with high spatial orientation.	Partially confirmed	The main effect of the 2D spatial orientation was confirmed for the fixations duration and the number of saccades. Additionally, the gaze metrics were statistically different for individuals with low and high 3D spatial orientation viewing floor plans with furniture.
H4B: Purchase intention scores will be higher for individuals with low spatial orientation when presented with 3D floor plans compared to 2D layouts.	Rejected	Purchase intention score is significantly higher for the participants viewing the 3D format floor plan than the 2D one. The effect

of spatial orientation in this relationship is statistically insignificant

4. Discussion

The presented study addressed a practical problem: determining which floor plan design types most effectively influence potential buyers' intention to purchase the viewed property. The study was carried out in an isolation from the homebuyers' socio-economic factors to assess the persuasive factors of floor plan design in a standardized environment where financial reach and requirements are already met. Using eye-tracking equipment, the experiment quantified potential homebuyers' gaze behavior in terms of viewing duration, fixation duration, number of fixations, and number of saccades. These metrics were cross-examined with floor plan formats (2D and 3D), design elements (base, color, and furniture), design perceptions (complexity, coherence, legibility), participants' familiarity with floor plans, and 2D and 3D spatial orientation skills.

The results suggest that, among the tested factors, the choice of floor plan format is a primary determinant of purchase intention, with the 3D format being favored by the studied population. The format significantly affects how potential homebuyers view the property layout, with 2D evoking prolonged and more detailed browsing than the 3D format. The combination of format and design elements of the property layouts also had a significant effect on viewing behavior. Colored 2D and furniture 3D layouts were associated with prolonged and spatially scattered viewing, while colored 3D layouts were characterized by the shortest and most focused viewing. Overall, gaze behavior did not have a mediating effect between floor plan design and purchase intention. Notably, while spatial orientation in 2D and 3D had no main significant effect, it moderated the relationship between floor plan design elements and the gaze behavior. Individuals with low 3D spatial orientation viewed property layouts with furniture for much shorter time and in less scattered way than individuals with high 3D spatial orientation. Finally, familiarity with floor plans acquired either through previous house search or the in-game maps had no significant main or moderating effect.

The anticipated mediating effect of gaze behavior and the connection between prolonged viewing of the floor plan and increased purchase intention (gaze cascade effect) described by Van Der Lans and Wedel (2017) and Simion and Shimojo (2006) were not confirmed in this study. This discrepancy may be due to the differing purchase context investigated in the literature and in this report. The previous studies examined purchase intention of the daily-use products that have no financial risk associated with them, therefore the gaze behavior had stronger purchase-predictive power. In the instance of a complex decision that is a choice of a house the gaze behavior alone may not have captured the nuances of the individual's evaluation. Even though this investigation purposefully omitted the socio-economic factors of the property purchase process, additional aspects such as emotions, aesthetic preferences, and current needs also play a significant role in the property purchase decision (Seiler et al., 2012) and they were not accounted for in this study. Therefore, while gaze behavior is informative for analyzing the customer choice process, it was not a main determinant of purchase intention.

Despite the lack of mediation, the analysis with gaze metrics provided valuable insights for real estate professionals regarding the optimal choice of floor plan format in order to attract and capture the visual attention. Due to the presence of labels with room names and dimensions, the 2D layouts provided potential homebuyers with additional visual cues, as noted by Shayestefar et al. (2022), leading to prolonged viewing times for interpreting the layout. Furthermore, the heatmaps presented in the *Results* section reveal that the 2D format evokes a *systematic viewing strategy*, comparable to retail shelves and shopping websites (Van Der Lans & Wedel, 2017). This organized viewing likely facilitates a structured mental image of the property, enhancing retention and its chances of being sold. The 3D format appears more effective in directing visual attention to key property features. Additionally, this type of visualization closely mirrored reality, helping participants find orientation points and familiar visual forms (e.g., furniture) within the floor plan, which is suggested to increase preference value respectively by Kaplan (1975) and Shayestefar et al. (2012). Therefore, based on gaze metrics, adopting the 3D floor plan format might be recommended to improve the effectiveness of real estate listings.

Independently of the gaze behavior, the investigation explored the significance of the design choices in shaping viewers' decision-making processes. Contrary to expectations, only the format of floor plans had a significant impact on purchase intention. This suggests that participants focused primarily on how compelling, realistic, and engaging the view of the property was, overshadowing the effect of individual design elements. This finding potentially aligns with the concept of the global precedence effect introduced by Navon (1977), confirming the power of the overall structure of the floor plan to influence viewers' first impressions. The fact that the effect of design elements was only significant when combined with the format further strengthens this argument. Favored by the population sample base 3D and colored 3D floor plans offer a clear and structured overview at first sight, with design elements that are easily recognizable. Therefore, it can be suggested that participants in the purchase orientation stage were primed by the overall design of the floor plans and were drawn to more comprehensible options at first sight.

Interestingly, the design elements and format did not impact homebuyers' purchase intention differently given their varied level of spatial orientation. This lack of effect can be partially explained by participants' comments. It seems like the format itself facilitated the understanding of the visualized property for the individuals to start mentally planning space utility regardless of the spatial orientation skills. Comments such as "I could quickly envision how the rooms would look" (P84), left by the participant viewing the 3D floor plan, indicate a sense of ease in visualizing and adapting to the space provided by the 3D format.

Additional comments collected via questionnaire revealed potential design improvement points. Participants had trouble finding the main entrance and identifying the role of "empty spaces" in each bedroom and hallway in the 2D floor plans. Comments such as, "There were two smaller sections which I first thought were toilets but then realized they were walk-in closets?" (P4) and "There was a weird space between two of the adjacent bedrooms" (P37) suggest that clear labeling of the closets would be a necessary design addition for 2D floor plans. Viewers of the base and colored 2D floor plans noticed the lack of fixtures and wished for them to be included. While labels in the 2D formats were appreciated, their absence in 3D formats was noted, with one participant saying, "I missed information about the sizes of the rooms, exact numbers" (P96). Despite this, many participants felt that "it was not completely needed as all the important things were shown in the floor plan" (P21). The white-grey color scheme of the 3D base floor plan was interpreted as too plain and not "distinguishable enough" (P43), resulting in participants' eyes being drawn to areas of high contrast, such as bathtubs, which was not desired. Similarly, the colored 3D floor plan design drew participants' attention to drastic details, such as differing wallpapers between two bedrooms, which does not facilitate the purchase decision. These design improvement points are necessary for real estate professionals to consider when deciding on which floor plan format and design elements are crucial for evoking purchase intention. The comments presented in this paragraph may give additional context to the justification of further findings.

Crucial insight in the customer purchase-decision process is offered when the two design components (format and elements) are combined to determine the complexity, coherence, and legibility of floor plans. One key observation is that, on average, participants' perception of the design aligned with the intended one. Confirming the definition by Pieters et al. (2010), participants generally found 3D floor plan designs much more complex than the 2D ones. The 3D floor plans offered more irregularity, detail of objects, and asymmetrical and irregular placement than the 2D layouts. The number of symbols/furniture, colors, and textures within each format group gradually increased the perceived complexity of the floor plan design. However, increasing complexity compromised the coherence and legibility of the floor plan design to some extent. Through the use of colors in the 2D group, the layout design visually clustered the rooms by their utility purposes, distinguishing different property zones and consequently enhancing perceived coherence and effective navigation of the layout compared to the first condition with only black-and-white wall depictions. This finding is in line with the assumptions of Shayestefar et al. (2022). However, contrary to expectations, the same design enhancement in the form of colors and textures in the 3D format did not fulfill its function. Compared to the base 3D layout, the floor plan with colors and textures was perceived as less coherent and less legible. This may be due to the use of more than three textures, recognized as the optimal number to achieve a balance between upholding viewers' attention and preserving high coherence of the design (Shayestefar et al., 2022). Moreover, the 3D floor plan with proposed furniture is an example of overcomplex design. Because it was considered “complex” (P129), “too detailed” (P89), and “chaotic” (P9), it significantly lowered its perceived coherence and legibility. Despite deviations from the anticipated hierarchy in floor plan types regarding complexity, coherence, and legibility, the overall trend of reflecting the design intentions in homebuyers' cognitive evaluations remains consistent.

The perceptions of the design on the complexity, coherence, and legibility dimensions have been reflected in the potential purchase intentions. The preference for the 3D base floor plan suggests that to enhance a property's marketability, the floor plan should facilitate easy mental navigation of the layout while maintaining a moderate level of complexity. Additionally, a highly legible floor plan should also strike a balance, ensuring an appropriate level of engagement. This can be observed in the purchase intention scores evoked by colored 2D and 3D floor plans, which ranked second among all floor plan types. Shayestefar et al. (2022) suggest that these floor plans were either too engaging (in the case of the 3D format, which utilized many textures), or not engaging enough (in the case of the 2D format, which offered too little visual stimulation and detail). The base 2D floor plan, characterized by high legibility but low complexity, evoked lesser purchase intention, indicating that while this layout may have practical use, it might not sufficiently persuade viewers. Therefore, it is crucial to design floor plans that not only enhance legibility but also maintain an optimal level of visual engagement to support better decision-making by potential buyers.

The lack of the effect of familiarity with floor plans on any gaze behavior is positive news for real estate professionals. It suggests that there is no need for special design adjustments to facilitate customer purchase decisions. Since house searches primarily have a utilitarian goal, it may not have been in the interest of participants with previous house search experience to retain much information about the structure of typical floor plans, especially the specific symbols used in the 2D format. Despite property layouts using less recognizable symbols, the overall schemas are universal. Conversely, due to their realism, the 3D floor plan elements can be recognized without specific prior knowledge. Therefore, the past experience with viewing property layouts, stemming from past purchases or in-game maps should not evoke different effects on purchase intention.

5. Limitations

First, there are limitations related to the presence of multicollinearity among the gaze behavior variables. This high degree of correlation between viewing and fixations duration and the number of fixations and saccades potentially masked the true impact of each individual gaze behavior metric, thereby limiting researcher's ability to identify more nuanced findings regarding how specific gaze patterns influence consumer decision-making.

Secondly, despite the best efforts, the researcher recognizes that parts of the data, primarily recordings of participants viewing the base 3D floor plan, may be subject to mapping errors due to the necessary manual aid of the picture recognition algorithm. Even though the eye behavior was meticulously reproduced, there may be inherent imperfections disturbing the representativeness of the results. Additionally, a more standardized way of determining the start and finish of the floor plan viewing might have increased the predictive power of the gaze metrics on the variables of interest. It is recognized that the time before and after enlarging the floor plan visualization to the big screen might have resulted in participants developing opinions that, due to omitting this part of the recording, were not reflected in the final results.

Thirdly, this investigation did not focus on the effect of personal preferences nor the floor plan design engagement, which may have affected the rationale of participants' purchase intention scores. Due to the limited scope, the study was primarily focused on producing recommendations for floor plan designs that can be universally implemented, without considering the wide range of subjective nuances.

6. Future research recommendation

Due to the limited scope and the anticipated characteristics of the convenience sample, this study did not include the effect of socio-economic factors of participants. Future studies should account for these factors to better mirror the real-life conditions of the house search process. Additionally, the potential impact of engagement and personal preferences should be considered.

Due to the learning curve effect observed by Dadi et al. (2014), this investigation chose to present participants with only one floor plan to assess the effect of floor plan design without accounting for familiarity with the property layouts shown within the same study. Future research should compare these findings with studies that align closer to the existing structure introduced by Van der Lans (2017), which may reveal the mediating effect of gaze. Limiting the viewing time of the floor plans might also help standardize the effect of gaze metrics and distinguish which property layout designs evoke more focused viewing and which mental images translate to higher purchase intention.

7. Practical implications

The study results suggest that the choice of the appropriate floor plan design significantly influences the purchase intention of potential home buyers. The 2D floor plans evoked an organized viewing strategy, potentially crucial for the mental image of the property and its remembrance. The realistic 3D floor plans, on the other hand, seem to enhance the property interpretation process the most, with the base one characterized by the highest purchase intention score. Crucial to consider is the choice of design elements and colors/textures used. Floor plans should primarily facilitate wayfinding and be coherent, grouping rooms of similar utility by colors or textures but limiting it to three distinct ones for optimal results. The addition of furniture and fixtures is highly desirable for participants, but their number and placement should be limited to avoid overstimulating the viewer in the already cognitively straining process of house searching.

8. Theoretical implications

This investigation used an interdisciplinary approach, drawing relevant theories and concepts from real estate, marketing, landscape preference, and gaming literature. It is recommended that perception scales of complexity, coherence, and legibility, drawn from landscape preference research, be further studied in the context of maps and real estate floor plans. In the rapidly developing technological world, the implementation of marketing literature is also recommended to explain rising phenomena in the real estate context. Furthermore, floor plans themselves hold great potential in providing insights in the house pre-purchase process. Their effect, largely understudied in the current literature, should not be omitted. Additionally, the use of eye-tracking methodology proved valuable in uncovering the effects of design and should be employed in future studies to gain deeper insights into how design elements influence viewer behavior and purchase intentions.

9. Conclusion

This study underscores the importance of leveraging advanced floor plan visualizations to influence home buyers' purchase intentions. Although the anticipated mediating effect of gaze behavior was not confirmed, the findings highlight the significant impact of 3D floor plans and well-designed elements on enhancing purchase intentions. Real estate professionals should prioritize creating coherent, easy-to-navigate floor plans that facilitate wayfinding and appeal to buyers' spatial orientation skills. By integrating insights from landscape preference literature and focusing on user-friendly design, the real estate industry can better meet the evolving needs of modern customers, ultimately driving higher purchase rates and satisfaction. The research utilizing eye-tracking on real estate floor plans is novel and provides valuable insights that can refine marketing strategies and improve property presentation.

References

Atalay, A. S., Bodur, H. O., & Rasolofoarison, D. (2012). Shining in the center: central gaze cascade effect on product choice. T*he Journal of Consumer Research/Journal of Consumer Research*, *39*(4), 848–866. https://doi.org/10.1086/665984

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173

Benefield, J. D., Cain, C. L., & Johnson, K. (2009). On the Relationship Between Property Price, Time-on-Market, and Photo Depictions in a Multiple Listing Service. *The Journal of Real Estate Finance and Economics*, *43*(3), 401–422. https://doi.org/10.1007/s11146-009-9219-6

Boumová, I., & Zdráhalová, J. (2016). The Apartment with the Best Floor Plan Layout: Architects versus Non-architects. *Critical Housing Analysis*, *3*(1), 1. https://doi.org/10.13060/23362839.2016.3.1.264

Dadi, G. B., Goodrum, P. M., Taylor, T. H., & Carswell, C. M. (2014). Cognitive workload demands using 2D and 3D spatial engineering information formats. *Journal of the Construction Division and Management*, *140*(5). https://doi.org/10.1061/(asce)co.1943-7862.0000827

De Leeuw, D., De Maeyer, P., & De Cock, L. (2020). A Gamification-Based approach on indoor wayfinding research. *ISPRS International Journal of Geo-information*, *9*(7), 423. https://doi.org/10.3390/ijgi9070423

Dong, W., & Liao, H. (2016). Eye Tracking To Explore The Impacts of Photorealistic 3D Representations in Pedestrian Navigation Performance. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 641-645.

Ekstrom, R. B., French, J. W., Harman, H. H., and Dermen, D. (1976). Manual for Kit of Factor-Referenced Cognitive Tests. *Educational Testing Service*, Princeton, New Jersey.

Gidlöf, K., Anikin, A., Lingonblad, M., & Wallin, A. (2017). Looking is buying. How visual attention and choice are affected by consumer preferences and properties of the supermarket shelf. *Appetite, 116*, 29–38. https://doi.org/10.1016/j.appet.2017.04.020

Goodrum, P. M., Miller, J. M., Sweany, J. B., & Alruwaythi, O. (2016). Influence of the format of engineering information and spatial cognition on Craft-Worker performance. Journal of Construction Engineering and Management, 142(9). https://doi.org/10.1061/(asce)co.1943-7862.0001157

Green, C. S., & Bavelier, D. (2006). *Effect of action video games on the spatial distribution of visuospatial attention. Journal of Experimental Psychology: Human Perception and Performance, 32(6), 1465–1478.* doi:10.1037/0096-1523.32.6.1465

Fixture. (2024). In *Cambridge Dictionary*. https://dictionary.cambridge.org/dictionary/learner-english/fixture

Floor plan. (2024). In *Merriam-Webster Dictionary*. https://www.merriam-webster.com/dictionary/floor%20plan

Gay, S., & Zhang, A. (2015). Marketing and product description: Value added in the real estate market. *Social Science Research Network*. https://doi.org/10.2139/ssrn.2690221

Hebdzyński, M. (2023). Quality information gaps in housing listings: Do words mean the same as pictures? *Journal of Housing and the Built Environment*, *38*(4), 2399–2425. https://doi.org/10.1007/s10901-023-10043-z

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review, 87*(4), 329–354. https://doi.org/10.1037/0033-295X.87.4.329

Kaplan, S. (1975). An informal model for the prediction of preference. In E. H. Zube, R. O. Brush, & J. G. Fabos (Eds.), Landscape assessment: values, perceptions, and resources (pp. 92–101). Stroudsberg, PA: Dowden, Hutchinson, & Ross.

Kaplan, R. & Kaplan, S. & Ryan, R. (1998). With People in Mind: Design And Management Of Everyday Nature. Bibliovault OAI Repository, the University of Chicago Press.

Lei, T. C., Wu, S. C., Chao, C. W., & Lee, S. H. (2014). Evaluating differences in spatial visual attention in wayfinding strategy when using 2D and 3D electronic maps. *GeoJournal*, *81*(2), 153–167. https://doi.org/10.1007/s10708-014-9605-3

Li, L., & Yavaş, A. (2015). The impact of a multiple listing service. *Real Estate Economics*, *43*(2), 471–506. https://doi.org/10.1111/1540-6229.12076

Luchtenberg, K. F., Seiler, M. J., & Sun, H. (2018). Listing agent signals: Does a picture paint a thousand words? *Journal of Real Estate Finance and Economics*, *59*(4), 617–648. https://doi.org/10.1007/s11146-018-9674-z

Martens, Y., & Koutamanis, A. (2003). Real estate online information systems. *Proceedings of the 21st International Conference on Education and Research in Computer Aided Architectural Design in Europe (eCAADe)*. https://doi.org/10.52842/conf.ecaade.2003.561

Moura, D., & El-Nasr, M. S. (2014). Design techniques for planning navigational systems in 3-D video games. *Computers in Entertainment*, *12*(2), 1–25. https://doi.org/10.1145/2701657.2633421

Murias, K., Kwok, K., Castillejo, A. G., Liu, I., & Iaria, G. (2016). The effects of video game use on performance in a virtual navigation task. *Computers in Human Behavior*, *58*, 398–406. https://doi.org/10.1016/j.chb.2016.01.020

National Association of REALTORS® Research Group (2022) Home Buyers and Sellers Generational Trends. https://www.nar.realtor/sites/default/files/documents/2022-home-buyers-and-sellers-generational-trends-03-23-2022.pdf

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology*, *9*(3), 353–383. https://doi.org/10.1016/0010-0285(77)90012-3

Pieters, R., Wedel, M., & Batra, R. (2010). The Stopping Power of Advertising: Measures and Effects of Visual Complexity. *Journal of Marketing*, *74*(5), 48–60. https://doi.org/10.1509/jmkg.74.5.048

Seiler, M. J., Madhavan, P., & Liechty, M. (2012). Toward an Understanding of Real Estate Homebuyer Internet Search behavior: An Application of Ocular Tracking Technology.

Journal of Real Estate Research, *34*(2), 211–242. https://doi.org/10.1080/10835547.2012.12091333

Simion, C., & Shimojo, S. (2006). Early interactions between orienting, visual sampling and decision making in facial preference. *Vision Research*, *46*(20), 3331–3335. https://doi.org/10.1016/j.visres.2006.04.019

Snopková, D., Švedová, H., Kubíček, P., & Stachoň, Z. (2019). Navigation in indoor environments: Does the type of visual learning stimulus matter? *ISPRS International Journal of Geo-information*, *8*(6), 251. https://doi.org/10.3390/ijgi8060251

Van Der Lans, R., & Wedel, M. (2017). Eye movements during search and choice. In *International series in management science/operations research/International series in operations research & management science* (pp. 331–359). https://doi.org/10.1007/978-3-319-56941-3_11

Von Castell, C., Oberfeld, D., & Hecht, H. (2014). The effect of furnishing on perceived spatial dimensions and spaciousness of interior space. *PLOS ONE*, *9*(11), e113267. https://doi.org/10.1371/journal.pone.0113267

Zanola, S., Fabrikant, S.I. & Çöltekin, A. (2009). The Effect of Realism on the Confidence in Spatial Data Quality in Stereoscopic 3D Displays. *Proceedings*, 24 th International Cartography Conference (ICC 2009), Santiago, Chile, Nov. 15-21, 2009

Zhang, A. T. (2014). Expertise value added in the real estate market. *Social Science Research Network*. https://doi.org/10.2139/ssrn.2515157

Zheng, M.-C. & Hsu, Y.-W. (2021). How 2.5D Maps Design Improve the Wayfinding Performance and Spatial Ability of Map Users. *Informatics* 2021, 8, 88. https://doi.org/10.3390/ informatics8040088

Appendix A: Questionnaire

Condition
This is an organizational question.
Enter the number provided to you by the researcher.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6

Consent
Dear participant,

Thank you for participating in this study. The study is part of the bachelor thesis concluding the Communication Science course at the University of Twente. The experiment utilizes eye-tracking technology to study the **eye-behavior influenced by the real estate floor plan types**. The research has been approved by the BMS Ethics committee.

This survey should not take you more than **20 minutes** to complete. The data will be used for research and educational purposes and stored securely offline. Participation is **anonymous**; this means that you don't have to disclose any identity information. Your answers are only visible for the researcher and her supervisors.

Your participation in this study is **entirely voluntary** and you can **withdraw at any time**. There are no known risks associated with this research study. Your answers in this study will remain confidential.

Thank you for your efforts.

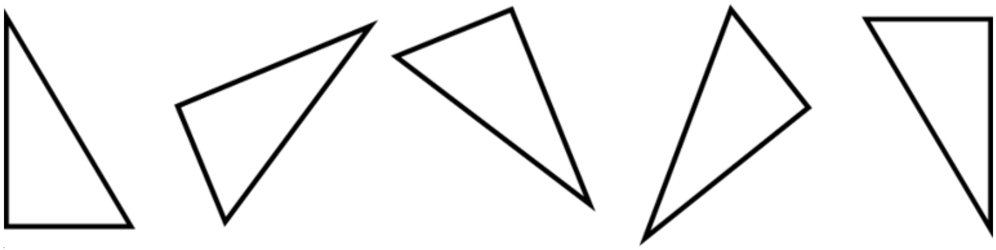
For more information, please contact the researcher on this address:
b.chrzescijanska@student.utwente.nl

Supervisor: Dr. M. Galetzka (m.galetzka@utwente.nl)
Secretary of the Ethics Commitee/domain Humanities & Social Science of the Faculty of BMS at University of Twente: ethicscommitee-hss@utwente.nl

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions or withdraw my participation at any time without providing a reason:

- ◯ Yes, I consent
- ◯ No, I do not consent

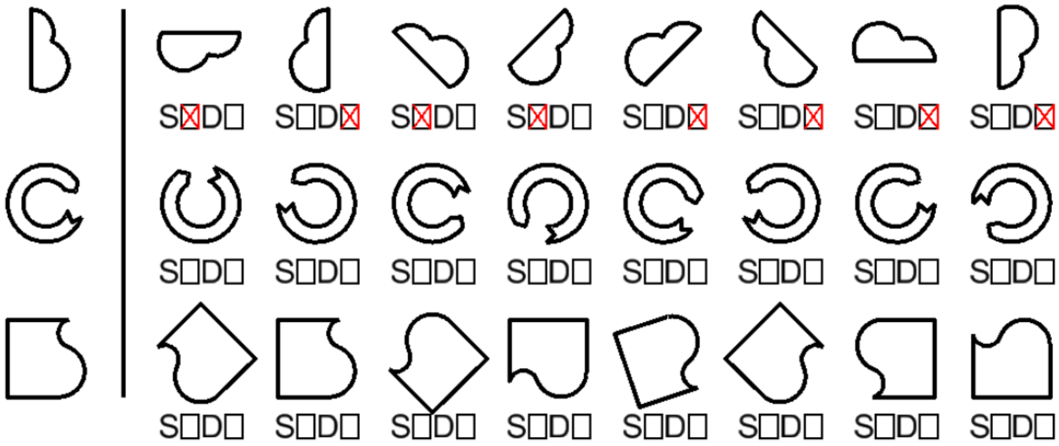
First, you are asked to fill in a test of your **ability to see differences in figures**.
Read the instructions carefully.
Look at the 5 triangle shaped cards drawn below. All of these drawings are of **the same card**, which has been slid around into different positions on the page.



Now look at the 2 cards below: **These two cards are not alike**. The first cannot be made to look like the second by sliding it around on the page. It would have to be **flipped over** or **made differently**.

Each problem in this test consists of one card on the left of a vertical line and eight cards on the right. You are to decide whether each of the eight cards on the right is the **same as** or **different from** the card at the left. Mark the box besides the S if it the **same as** the one at the beginning of the row. Mark the box beside the D if it is **different from** the one at the beginning of the row.

You can practice on the following rows. The first row has been correctly marked for you. Click on the rectangle box place near the S or D letters to mark the answer you think is correct.



Your score on this test will be the number of items answered correctly minus the number answered incorrectly. Therefore, **it will not be to your advantage to guess**, unless you have some idea whether the card is the same of different. Work as quickly as you can without sacrificing accuracy.

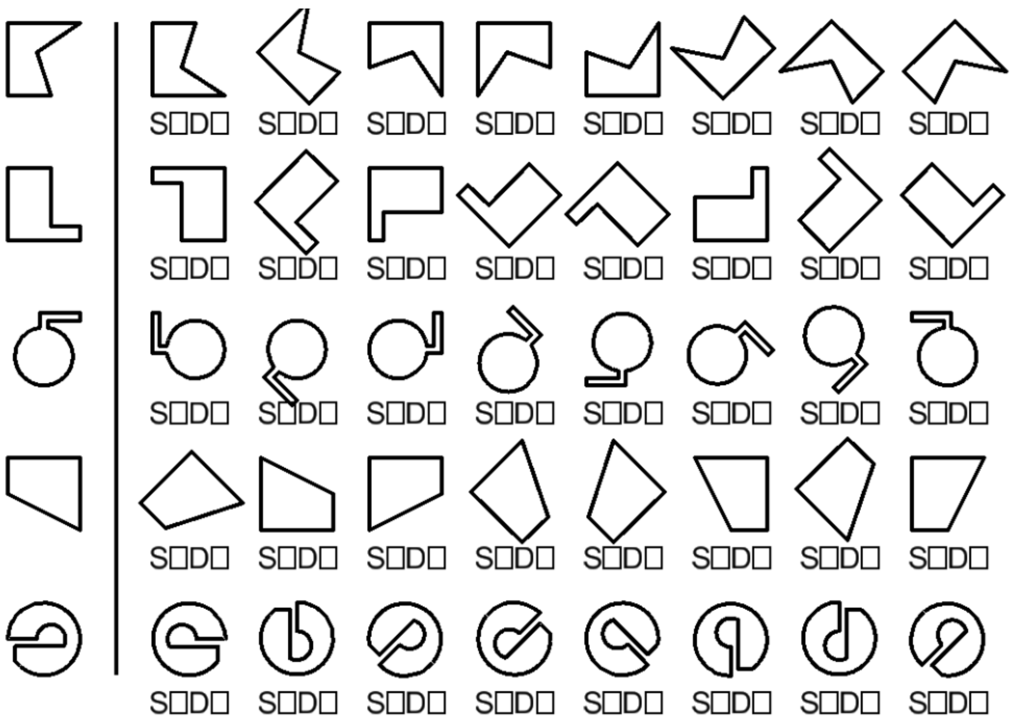
You will have 1.5 minutes for this test. **When you have finished this test, you can continue to the next page.** In case you run out of time the following page will load automatically.

When you're ready to take the test continue to the next page.

Card Rotation Test (1.5 minutes)

S = same (only rotated)

D = different (flipped and/or rotated)

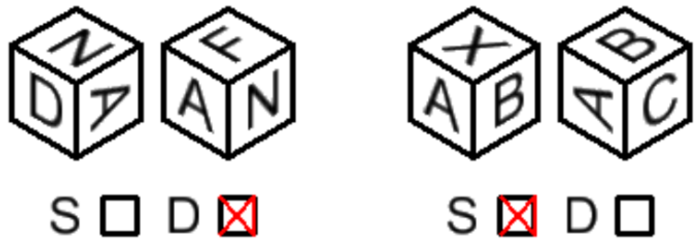


Thank you for filling in the first test. Next you are asked to fill in a similar test of your **ability to compare objects in 3D**.

Read the instructions carefully

Wooden blocks, such as ones children play with, are often cubical with a different letter, number, or symbol on each of the six faces (top, bottom, four sides). Each problem in this test consists of a drawing of pairs of cubes or blocks of this kind. Remember, **there is a different design, number, or letter on each face of a given cube or block**.

Compare the two cubes in each pair below.



*The first pair is marked D because they must be drawings of different cubes. If the left cube is turned so that the A is upright and facing you, the N would be to the left of the A and hidden, not to the right of the A as is shown on the right hand member of the pair. Thus, the **two drawings must be of different cubes**.*

*The second pair is marked S because they could be drawings of the same cube. That is, if the A is turned on its side the X becomes hidden, the B is now on top, and the C (which was hidden) now appears. Thus the **two drawings could be of the same cube**.*

Note: No letters appear on more than one face of a given cube. Except for that, any letter can be on the hidden faces of a cube.

Practice on the three examples below. Click on the rectangle box place near the S or D letters to mark the answer you think is correct.

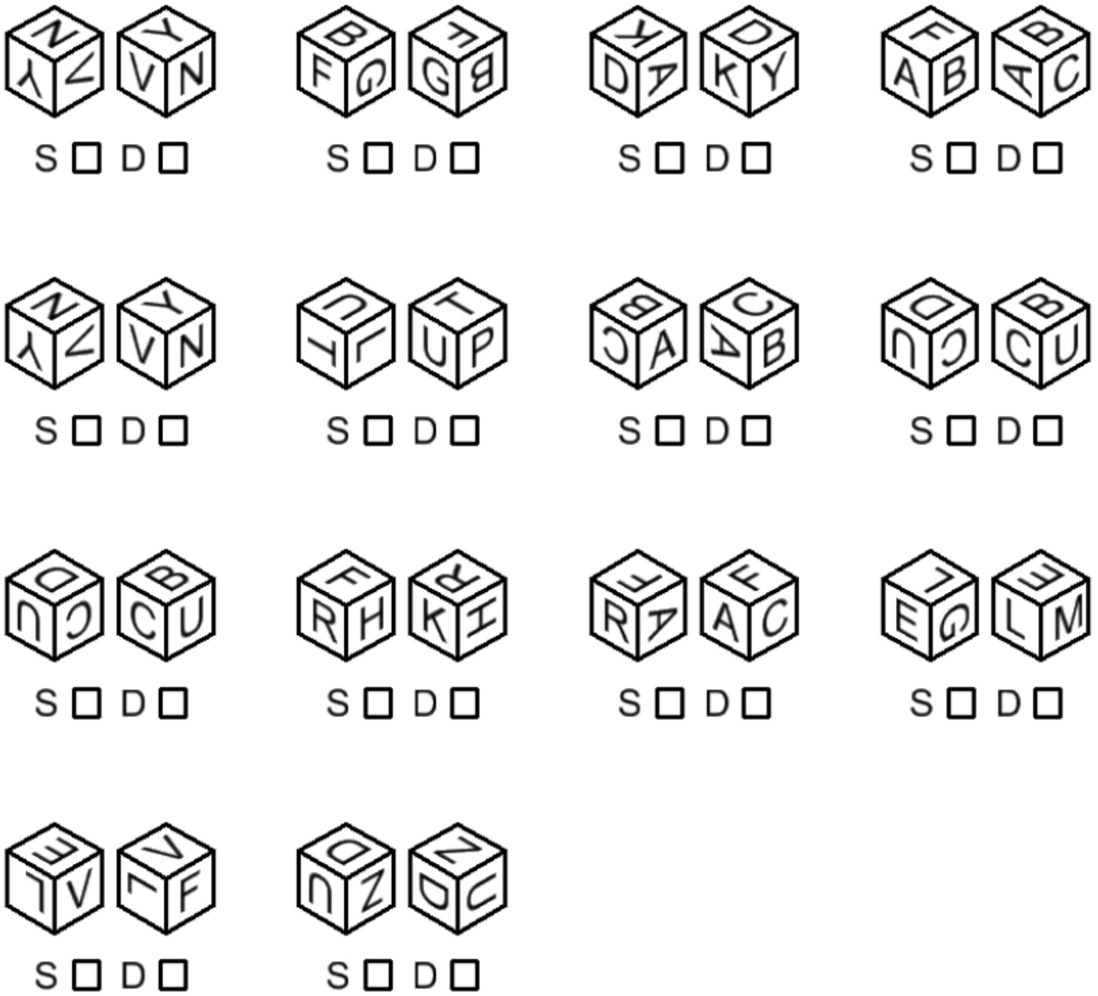
Your score on this test will be the number marked correctly minus the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you have some idea which choice is correct. Work as quickly as you can without sacrificing accuracy.

You will have 2 minutes for this test. **When you have finished this test, you can continue to the next page**. In case you run out of time the following page will load automatically.

When you're ready to take the test continue to the next page.

Card Rotation Test (2 minutes)

S = same (only rotated)
D = different (flipped and/or rotated)



Thank you for filling out the Cube Comparison test!

In a final step before presenting you with a floor plan we want to ask you a few questions about your previous experiences. Please answer them according to your best knowledge.

Experience_fp
Think of the last time you were searching for a property to buy or rent, or a room to rent. During that search, did you look at the floor plan (layout) of the property?

(*A floor plan is a drawing that shows the layout and dimensions of a property's rooms and spaces.*)

- ◯ Yes
- ◯ Not sure
- ◯ No

Experience_games
Do you have experience playing video games that involve map navigation, such as navigating through landmarks or buildings?

(*The map here is referred to as a 2-D representation that shows the 3-D world from a top-down view. Maps can be accessed through the game menu, or on the side of the screen, with or without a GPS marker. Think about titles such as Minecraft, Assassin's Creed, or Grand Theft Auto.*)

- ◯ Yes
- ◯ No

Intro fp1
In a moment you will view a layout of the property.

Pretend that you are currently searching to buy a new house. **During your search you encounter an apartment that fits your budget and search criteria.** Take a look at the floor plan of the property. Take as much as you need to understand the structure of the house. **There are no time limits here.**

Once you determine that you have a good understanding of the property displayed on the floor plan, continue the survey. In the following questions you will be asked about your overall impression of the property layout.

When on the next page make sure to click on the picture of the floor plan to expand it to the full screen.

Please determine in which language do you prefer to see the labels within the property. When you are ready to view the floor plan, continue to the next page.

- ◯ English
- ◯ Dutch

Complexity_0
On a scale from 'not complex at all' to 'very complex' how would you describe the floor plan you just have viewed?

(*Think of how rich in the design was the property layout*)

	Not complex at all	Somewhat not complex	Neutral	Somewhat complex	Very complex
The floor plan design was...	◯	◯	◯	◯	◯

Complexity
Please determine to what extent do you agree with the following statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The floor plan is densely packed with information	◯	◯	◯	◯	◯
There are a lot of things to look at within the floor plan	◯	◯	◯	◯	◯
The floor plan displayed elements of different kinds	◯	◯	◯	◯	◯
There is a high level of detail in this floor plan	◯	◯	◯	◯	◯

Coherence_0

On a scale from 'not coherent at all' to 'very coherent' how would you describe the floor plan you just have viewed?

(*Think of how well the property layout "hanged together"*)

	Not coherent at all	Somewhat not coherent	Neutral	Somewhat coherent	Very coherent
The floor plan design was...	○	○	○	○	○

Coherence

Please determine to what extent do you agree with the following statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The structure of the floor plan was logical	○	○	○	○	○
The layout was clear and organized	○	○	○	○	○
It is easy to see how different spaces in this floor plan connect with each other	○	○	○	○	○
I can easily understand how different parts of the floor plan relate to each other	○	○	○	○	○

Legibility_0

On a scale from 'not legible at all' to 'very legible' how would you describe the floor plan you just have viewed?

(*Legibility refers to way-finding. Think of how easy it is to navigate through the property layout*.)

	Not legible at all	Somewhat not legible	Neutral	Somewhat legible	Very legible
The floor plan design was...	○	○	○	○	○

Legibility

Please determine to what extent do you agree with the following statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
It was easy for me to mentally navigate through the layout	○	○	○	○	○
I can quickly find important information such as room key features in this floor plan	○	○	○	○	○
The symbols and room labels used in the floor plan are clear and understandable	○	○	○	○	○
This floor plan is visually easy to understand	○	○	○	○	○

Purchase_intention
Based just on the visual aspects of the floor plan you have just viewed during your house search, how likely are you to consider buying this property?

(*think about the attractiveness, complexity, coherence, ease of navigation of the floor plan*)

	Extremely unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely
I am...	○	○	○	○	○

Additional_comment
Is there anything you would like to add regarding your opinion on the floor plan you just viewed?

Demographics
Thank you for sharing your perception on the floor plan!
As the very last task we would like to ask you to share your demographic data.

Age
What is your age?

Gender
What is your gender?

○ Male

○ Female

○ Non-binary / third gender

○ Prefer not to say

Nationality
What is your nationality?

○ Dutch

○ Other (please specify) ____

Appendix B: AI use statement

During the preparation of this work the author used ChatGPT and Grammarly software in order to improve the language, correct grammatical errors, and rephrase hard-to-understand sentences in relevant parts of the report. After using those softwares, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.