Interaction Augmentation: Deepening User Experience to Build Placeness

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Various forms of interaction derived from nonverbal behaviors of products contribute to delivering positive experiences in human-product interactions. For a product to be integrated into human experiences more closely, it must incorporate aspects of the spatial environment in which it is placed. Although numerous previous studies have suggested that expanded experiences extending from the product to the surrounding space play a crucial role in the formation of placeness, place attachment, and behavioral intentions, the structured pathways and the clarities of how product interaction contributes to placemaking remain underexplored. This study aims to structure and elucidate whether and how a product, depending on its placement and spatial context, influences individuals' memories and impressions. It focuses on examining whether product interaction fosters place attachment and promotes behavioral intentions. To address these objectives, we suggest a new concept “Interaction Augmentation” and an interactive lighting product incorporating anthropomorphized interactions was designed. Both emotional evaluation and placeness evaluation were conducted through quantitative and qualitative research. The results confirm that product design and interaction planning can extend to fostering memory and formation of meaning within users’ spatial environments. Furthermore, the study emphasizes the strategic importance of emotional design elements—especially "Appealing" and "Comfortable"—for reinforcing placeness. Designers of interactive products should recognize that micro-interactions within spaces or products can be augmented to influence individuals' contextual memories and experiences in a place, while also understanding how to encourage user behavioral intentions.

Keywords: interaction; placeness; user experience; anthropomorphic

1 Introduction

1.1 The human–place relationship

In the context of understanding how environments contribute to the formation of a sense of place in relation to individuals, a wide range of studies have been carried out across the social sciences, including environmental psychology, sociology, and community psychology. Scannell and Gifford (2010) emphasized the cognitive connections that constitute place attachment from a personal perspective, such as emotional affection for a location and the perceived significance it holds. Similarly, Lewicka (2011) identified that even in a highly mobile modern society, people continue to develop strong attachments to particular places. Also, Gustafson (2001) analyzed the relationship between place attachment and mobility (referring not only to physical movement but also to social, professional, and cultural transitions and the dynamic interplay between local and global contexts in contemporary life) from a sociological standpoint. Although scholarly interest in human-place relationships has steadily increased, the majority of related research has been concentrated in social science journals, while design-oriented investigations into placeness and human interaction remain relatively underrepresented.

1.2 The human–product relationship

The exploration of relationship formation with humans is equally applicable in the field of design. According to an analysis by Mugge (2009) on the impact of interaction centered design elements on user experience, many products that interact with humans primarily aim for practicality. However, they are also expected to pursue social value in the process and provide users comfort and enjoyment through product use. Furthermore, numerous studies have examined the influence of anthropomorphized interaction characteristics of products on human behavior. The study by Alabed et al (2022) revealed that the interaction characteristics of products significantly affect human behavior. These findings underscore the need for collaborative attention among all stakeholders involved in product development—including form-focused designers, usability experts, and engineers—to better understand and design product interactions. Numerous studies have already shown that even basic physical interactions with products can shape positive impressions and influence purchase intentions. Li (2023) demonstrated that interaction-based cues have a greater impact on consumers' buying decisions and help reduce the psychological distance between the user and the product. However, few studies have explored the relationship between product interaction and placeness from a contextual perspective. The study of human relationships is inherently interdisciplinary and can benefit from integrative approaches. Human behaviors and memory formation are influenced by diverse stimuli and interactions that individuals encounter, and these experiences are not neatly confined to a single academic field (Conway, 2000). As such, a comprehensive understanding of behavior requires insights from psychology, neuroscience, design, sociology, and cognitive science.

1.3 The Spatial context

A clear example of how products contribute to the formation of place attachment is the “Maneki-neko” commonly seen at the entrance of Japanese restaurants. This waving cat figurine, while seemingly a simple object, becomes a spatial symbol when placed in the specific context of a restaurant entryway. Its waving gesture is interpreted as a welcoming message, which, when

associated with the entrance, becomes a memorable and meaningful experience. These types of experiences contribute to a lasting sense of place and are often shared with others.

As demonstrated by this example, a product can leave a strong impression not only through its own features but also through the spatial and contextual associations it fosters. This idea served as the conceptual starting point of the present research. Accordingly, the aim of this study is to explore the impact of product interaction on placeness, explain the theoretical pathways through which its subcomponents influence behavioral intentions, and provide empirical evidence to support these relationships.

2 . Literature Review

2.1 Placeness

Placeness refers to the emotional and cognitive bonds formed through interactions with specific locations, shaped by the accumulation of personal memories and experiences. This environmental attachment provides individuals with restorative attention, emotional recovery, and a sense of physical and psychological stability, ultimately playing a vital role in relieving everyday stress (Hartig et al., 2001; Kaplan, 1995). For instance, when someone feels that “this space was joyful,” that place transcends its physical dimensions and becomes embedded in the individual’s life. Furthermore, places can offer psychological comfort and emotional stability, which are essential factors in the development of place attachment (Korpela & Hartig, 1996). According to Vaske and Kobrin (2001), place attachment is a critical subcomponent of placeness. Placeness is influenced by individuals’ memories and emotional experiences associated with certain locations, which in turn contribute to the development of place attachment. Over time, this attachment can influence behavior, such as repeatedly visiting a favored location or recommending it to others.

More specifically, place attachment can be understood as a subjective recognition formed through various interactions experienced in a place—interactions encompassing cognition, beliefs, and emotions. These perceptions, shaped by personal preferences, past experiences, beliefs, and emotional states, act as key factors in forming strong bonds with places. In particular, Halpenny (2010) conducted an experimental study examining how place attachment affects behavioral intentions. Focusing on Canada’s Point Pelee National Park, she found that individuals with strong place attachment were more inclined to protect the location, recommend it to others, and revisit it in the future. This suggests that place attachment can lead to meaningful behavioral outcomes beyond simple emotional bonds. Dalavong and Im (2024) also explored the influence of placeness on behavioral intention. Their findings revealed that placeness does not directly affect behavioral intention but rather exerts its influence indirectly through place attachment. In other words, emotional bonds formed with a location contribute to attachment, which in turn plays a decisive role in shaping behavioral intention.

A visual representation summarizing the relationships among placeness, place attachment, and behavioral intention is presented as follows.

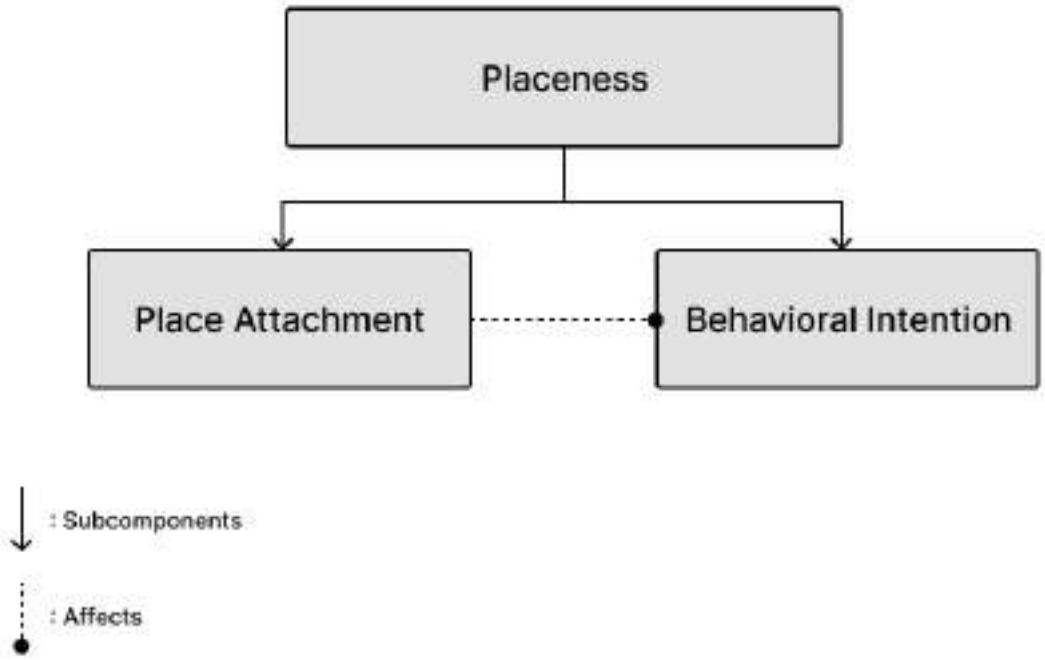

Figure 1. A Conceptual Framework Illustrating the Relationship Between Placeness, Place Attachment, and Behavioral Intention

2.2 Micro-interactions & Augmenting Interactions

There are numerous factors that help people form lasting memories of products. These may include product's appearance, innovative technologies, or captivating marketing messages. Among these, the shape and appearance of a product play a pivotal role in how it is perceived, approached, and eventually integrated into a long-term relationship with the user. Research has also examined how sensory feedback from products influences consumer preference.

One concept here is micro-interaction. The field of user experience (UX) design has been central in defining and applying this concept. In his book *Micro-interactions: Designing with Details*, Dan Saffer (2013) defines micro-interactions as:

"Micro-interactions are contained product moments that do one small task."

This definition refers to small, independent product behaviors triggered by changes in system or product states. In mobile environments, actions such as button clicks or screen swipes themselves constitute micro-interactions, while in tangible products, operations such as switching on/off or rotating the body of the device can also be categorized within the scope of micro-interactions.

In summary, the archetype of micro-interactions is the "execution of function," and when augmented, an element of "delight" is added. We define interactions that add physical depth to these small hand-driven actions—i.e., micro-interactions required to operate a product—as the "augmentation" of micro-interactions. Micro-interactions that are solely functional are limited in their ability to convey expressive and intentional behavior effectively. In other words, micro-interactions limited to mere functional execution may not sufficiently provide users with a positive experience. However, when expressive elements are incorporated to augment these interactions, the potential to deliver a more positive and meaningful user experience is significantly enhanced. Therefore, the augmentation of

micro-interactions, which combines expressive capacity with functional considerations, contributes to the creation of more engaging and meaningful interactions.

3 Method and Hypotheses

3.1 Product Form Design

Figure 2. Examples of micro-interactions

Based on prior studies and insights into micro-interactions and interaction augmentations, a mechanical design engineer and a control system engineer developed the interactive product through the following design process. Our product aims not only to fulfill functional purposes but also to promote emotional and sensory interaction with users. Lighting products, by mediating the intangible element of light, hold particular potential to establish emotional connections with users.

In designing the interactive lighting product, we adopted the Research through Design (RtD) methodology. RtD is a research approach that generates knowledge through the practice of design, based on the premise that design activity itself serves as a means of inquiry, allowing for the derivation of new insights and theoretical understanding through both the final design outcome and its development process (Frayling, 1993).

Our RtD process involved iterative exploration of motion patterns, form, color, and material selections, specifically targeting the entryway—the space people encounter first when entering or last when leaving the home. We repeatedly iterated between motion and form design to effectively convey the intended behaviors and product states to users, reflecting the core principle of RtD: to explore problems and solutions simultaneously as they emerge during the design process.

3.1.1 Motion Design Iterations

We initially explored three primary greeting gestures: waving, bowing, and nodding. Through early prototyping, we eliminated waving motions due to the spatial constraints of fixed lighting fixtures and the mechanical complexity required for lateral movements. Bowing gestures, while culturally meaningful, presented concerns about cultural specificity and potential misinterpretation across different contexts. The nodding motion emerged as the optimal choice due to its universal recognition as a greeting gesture across many cultures, mechanical simplicity requiring only single-axis rotation, and semantic clarity in conveying acknowledgment and welcome even with minimal structural complexity.

We interpreted the 'lighting up' of the entryway as a concept of farewell and welcome, aiming to augment this simple illumination into a more meaningful interaction. The nodding gesture was inspired by the act of tipping one's hat as a greeting—a representative expression of welcome that transcends cultural boundaries. Since lighting products are functionally required to remain fixed in place, large-scale motion is typically constrained, making the nodding gesture a spatially economical yet interactionally meaningful form of augmentation.

3.1.2 Form Development

The anthropomorphic form of a person wearing a hat was selected to create an immediate visual connection with the tipping-hat greeting gesture. Early iterations explored more abstract rounded forms, but user feedback during informal prototyping indicated ambiguity in the gesture's intention. The hat silhouette provided clearer affordance for the nodding interaction, making the greeting gesture immediately recognizable.

3.1.3 CMF Decisions

The product utilized polished orange ABS plastic for the lamp body. Orange was selected for its warm, welcoming associations—qualities intended to reinforce the greeting gesture. However, our RtD process did not systematically explore how this vibrant color would harmonize with diverse residential interiors or consider alternative palettes (e.g., neutral tones). This limitation emerged in qualitative findings, where participants noted concerns about color compatibility with existing furnishings (Section 4.3.2), revealing that our design iterations focused more rigorously on motion than on contextual color appropriateness. While our RtD iterations rigorously developed the motion interaction, we recognize that tangible design elements (color palette variations, material textures,

form refinements) received less systematic exploration. This represents a limitation in our design approach, as the subsequent experimental results revealed that these physical characteristics significantly influenced users' perceptions of comfort and spatial integration.

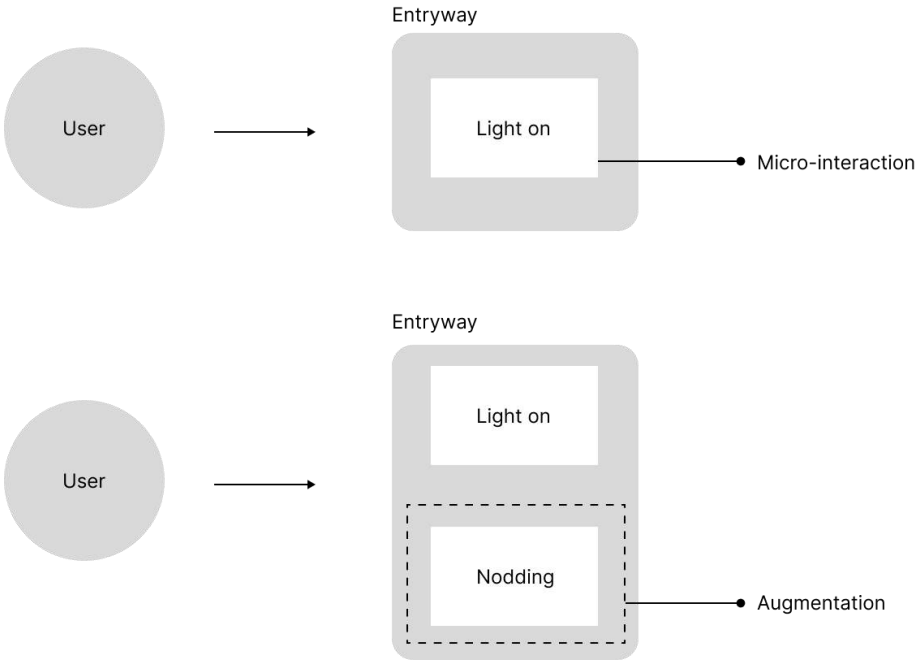

Figure 3. Examples of the concepts of micro-interaction and augmentation

3.2 Theoretical Rationale for Augmentation

Previous research has shown that interactive behaviors requesting a response, as opposed to passive viewing experiences, leave a stronger impression in memory and user experience (Howard et al., 2022). Because the nodding gesture inherently involves a structure of both recognition and response, it is well-suited for expanding product behavior from functional reactivity to intended responsiveness. Thus, the nodding motion of the lighting—paired with its activation—serves as a non-verbal cue that goes beyond a simple physical response, inviting an emotional experience rooted in spatial and cultural grammar. It represents a prototypical case of emotion-driven, place-based design, where the user feels welcomed upon entering the space. This incorporation of motion into a simple lighting function constitutes an augmentation of micro-interaction, which lies at the core of what this study aims to define as 'Augmentation'.

As shown in Figure 4, the lamp's head was anthropomorphized to resemble a person wearing a hat, with the "neck" rotating approximately 20 degrees to simulate a nodding gesture.

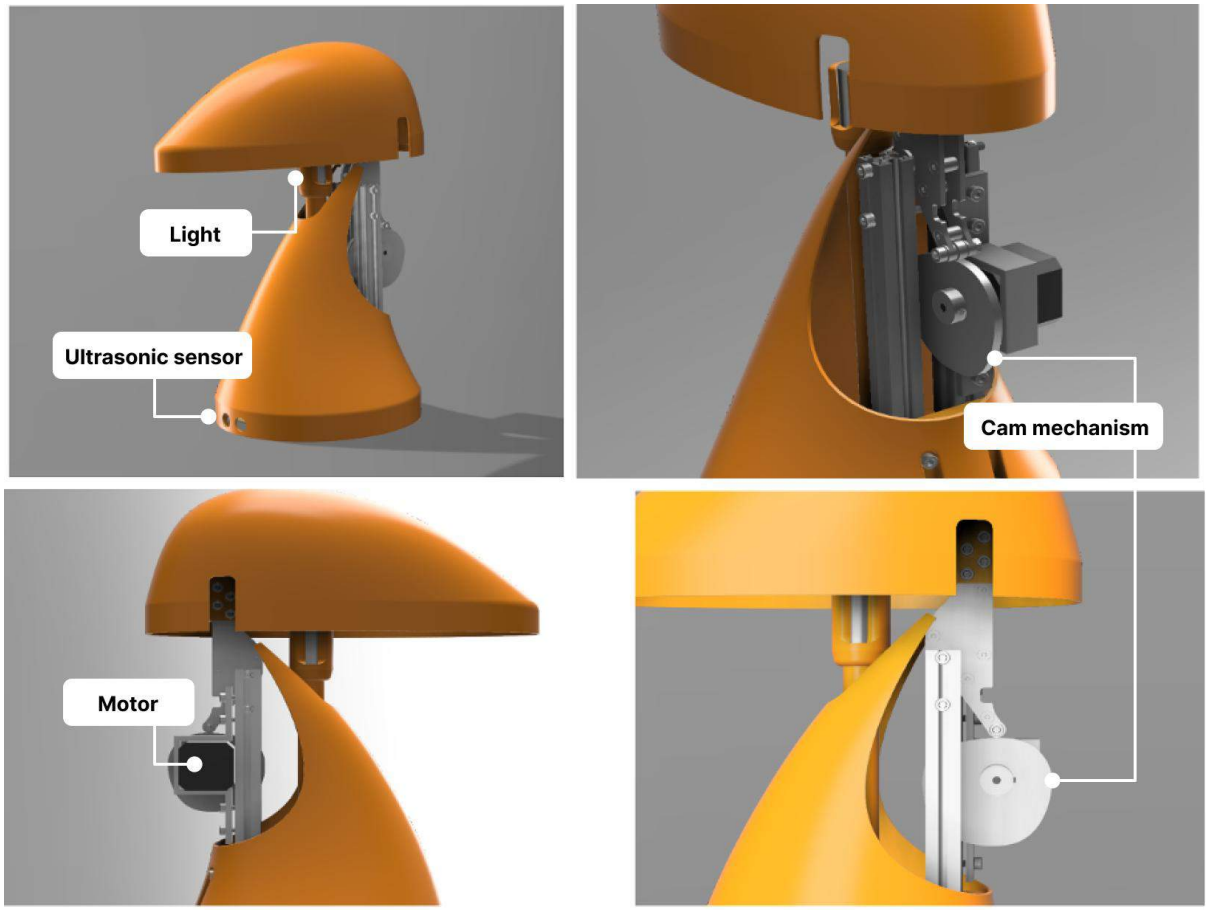

Figure 4. Hardware configuration of interaction lighting

Figure 5. Design of interaction lighting

3.3 Implementation and Evaluation Scenarios

To implement the robotic nodding motion in the product, an ultrasonic sensor was attached to the front of the lamp to detect user movement, allowing it to automatically initiate a nodding motion and turn on the light when a person is detected.

Through iterative design processes, we developed two user evaluation scenarios. In the first scenario (W/O), only the light turns on as a user approaches. In the second scenario (W), the light turns on and performs the nodding motion simultaneously. One of the core research questions is whether the dynamic expression of the product can enhance users' perception and interaction experience. These scenarios allow for experimental assessment of how the product's physical motion and sensory feedback affect users.

3.4 Hypotheses

This study aims to address a gap in prior research by exploring how product interaction influences placeness, based on structural pathways identified in previous studies. Specifically, we seek to understand how positive user experiences, triggered by product interaction, contribute to the formation of place attachment and behavioral intention. To identify the pathway from product interaction to placeness, we propose the following research questions and hypotheses:

RQ1: Will users evaluate the lighting product with expressive movement more positively?

H1: Users will perceive the anthropomorphized lighting product (W) as more organic, human-like, intelligent, and comfortable compared to the non-interactive version (W/O).

H1 was measured through five evaluation factors—Organic, Lively, Appealing, Intelligent, Comfortable—to investigate the specific elements of positive perception influenced by interaction. These factors were measured using the Godspeed Questionnaire, a standardized tool for evaluating anthropomorphized systems developed by Bartneck et al. (2009). The questionnaire assesses how human-like and lifelike the interaction appears, how friendly and intelligent it feels, and whether the expression feels stable and comfortable. It plays a critical role in evaluating how product interaction influences the formation of cognitive and emotional responses, and in determining whether these responses are perceived positively by users.

Moreover, we hypothesize that the interaction of the lighting product will have an influence on the formation of place attachment and behavioral intention. We suggest that the product's movement contributes not only to a favorable impression of the product itself but also to memory formation and emotional resonance with the physical space in which it is installed. Based on existing literature, placeness is evaluated from two perspectives: the formation of place attachment, which stimulates the psychological dimensions of a place, and the formation of behavioral intention, which reflects the user's willingness to actively promote the space to others based on their memory of it.

RQ2: Does the anthropomorphic interaction of the lighting product influence place attachment?

H2: Users will associate the lighting interaction with the space, leading to emotional memory formation and comfort—stimulating the affective (A) aspect of placeness.

RQ3: Does the anthropomorphic interaction of the lighting product influence behavioral intention toward the place?

H3: The lighting interaction will motivate users to revisit or invite others to the space—stimulating the intentional (I) aspect of placeness.

To measure place attachment, this study constructed a questionnaire composed of items that capture respondents' psychological states, experiences, and perceptions when observing the lighting product. This approach aims to assess the conditions for the formation of place attachment at the individual level, focusing on how people personally perceive and interpret a given place. The evaluation items were derived from prior studies by Jorgensen and Stedman (2001) and Scannell and Gifford (2010), which structurally interpreted place attachment based on the concepts of place identity and place dependence. According to these studies, place attachment extends beyond simple emotional bonding and consists of three dimensions: Person, Place, and Process. This structure directly influences individuals' perception and interpretation of place. For instance, a particular park may not be frequented solely because of its proximity, but rather because the individual perceives it as a place of emotional significance, leading to repeated use.

By integrating the approaches to measuring place attachment presented in previous studies, this research organizes place attachment into the following three evaluation factors. First, place attachment is assessed in terms of whether it alters cognitive processing to enhance memory related to a specific place. Second, it is evaluated based on whether emotional bonding with the place leads to feelings of comfort and stability within that environment. Third, by considering the influence of a place's inherent characteristics and symbolic meanings on attachment formation, it assesses the extent to which the unique attributes of the place contribute to the development of place attachment.

Meanwhile, the measurement of behavioural intention was composed of items designed to assess whether positive evaluations of interaction—when observing the lighting product—lead to positive cognitive and emotional responses, ultimately motivating users toward behavioural outcomes. These items aim to measure how interaction experiences with the product influence users' attitudes toward the place and their behavioural responses. Studies on place image by Echtner and Ritchie (1993) and Kang and Choi (2012) also suggest that place attachment goes beyond emotional bonding and can lead to specific behavioural intentions, such as intentions to revisit, speak positively about the place to others, or invite others to the location.

The approach to measuring behavioral intention is summarized into the following three evaluation factors. First, it assesses the tendency to speak positively about the space where the product is placed, considering behaviors that involve sharing favorable memories of the space with others. Second, it evaluates whether the formation of sense of place leads to the motivation to revisit the space in the future. Third, it examines whether behavioral intention extends beyond personal revisitation to include the willingness to actively invite others to the space.

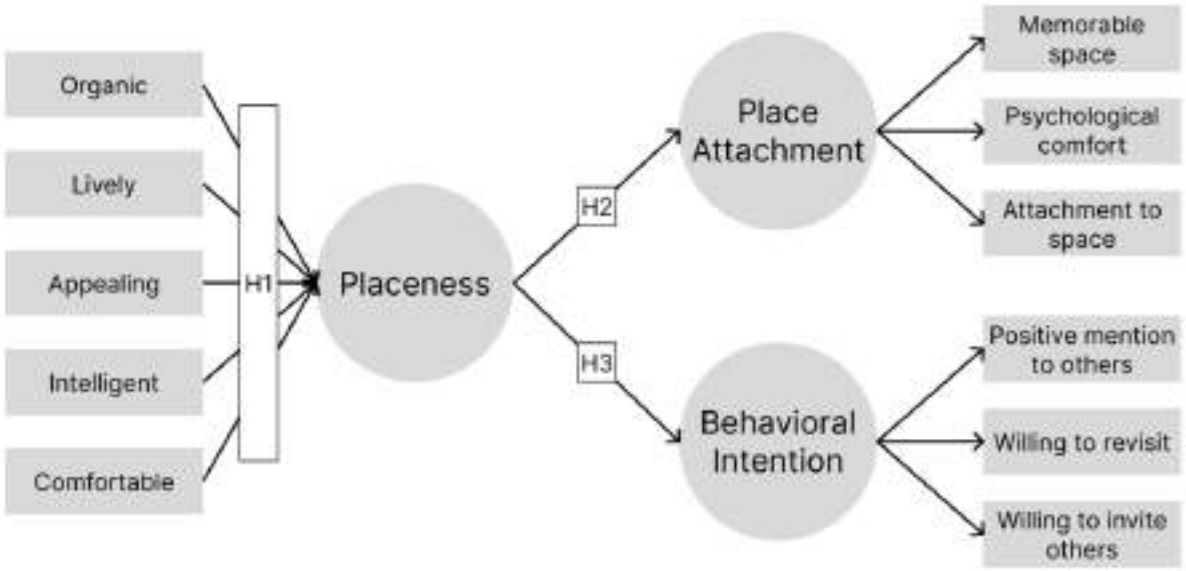

Figure 6. A Framework of the Hypothesis

Table 1. Survey Questions on Interaction Experience by Place Attachment and Behavioural Intentions

	Place Attachment
A 01	Because of this product, this space will be memorable for me
A 02	Because of this product, this space will give me psychological comfort
A 03	Because of this product, this space will make me develop attachment
	Behavioural Intention
I 01	Because of this product, I will speak positively about this space to others
I 02	Because of this product, I want to revisit this place
I 03	Because of this product, I want to invite others to this space

3.5 Measurement

To measure the theoretical framework presented, we designed an experiment in which each participant was shown a video of the lighting product in operation. Two short video clips (each 8 seconds) were produced under the same environmental conditions. Video A showed a standard lighting product turning on without movement, while Video B demonstrated an anthropomorphic interaction, where the lighting nods as a user approaches.

This video-based experimental design allowed for a controlled comparison between the two interaction styles under identical conditions, with variables such as brightness, distance, and background held constant (Höök, 2018).

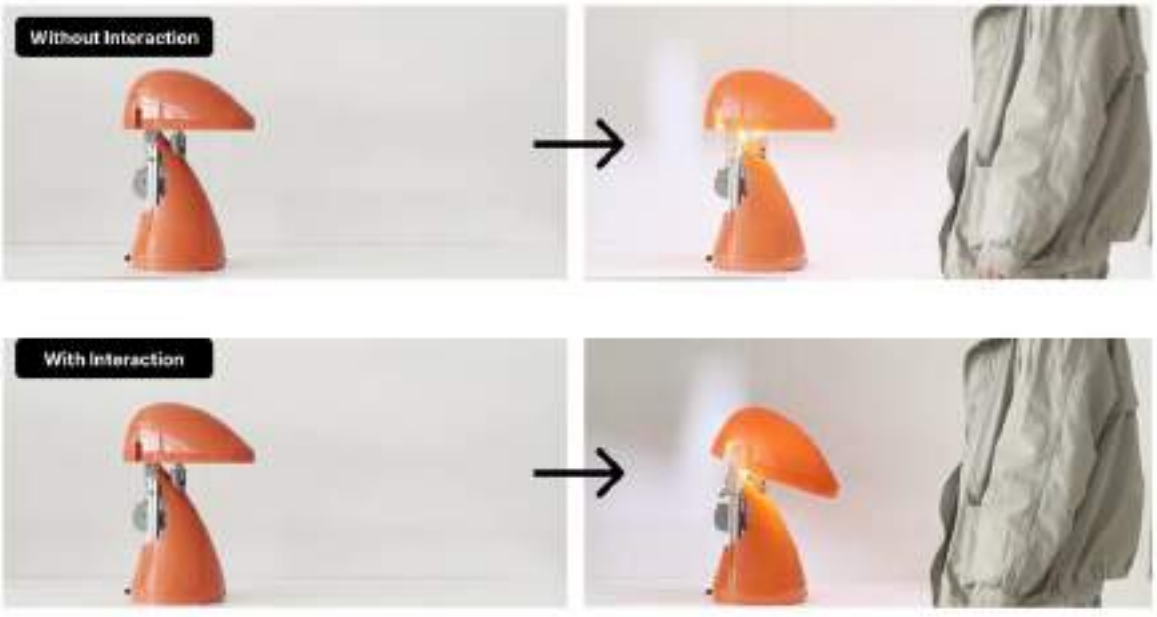

Figure 7. Video-based experiment for positive evaluation experiment based on the presence or absence of product interaction

The experiment was conducted through an online survey, with ethical considerations upheld via informed consent from participants. The survey was administered from April 5 to April 13, 2025, and was composed of four sections:

The first section collected demographic data including gender, age, and major. The second section presented the lighting products with and without anthropomorphic interaction (W/O and W) and measured the five perceptual factors in H1 (Organic, Lively, Appealing, Intelligent, Comfortable). The third section examined the influence on placeness by testing Hypothesis 2 (H2) for Place Attachment (A) and Hypothesis 3 (H3) for Behavioral Intention (I), comparing responses under both W/O and W conditions. All items in the second and third sections were measured using a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Finally, the fourth section asked participants whether they would prefer to place the interactive lighting product (W) in their actual living space. Participants were also prompted to provide open-ended responses explaining their choice, enabling us to gather qualitative insights.

This study employed video-based stimuli (8-second clips) to ensure controlled comparison between conditions. While this approach enabled systematic evaluation under identical conditions, we acknowledge that it does not fully capture the spatial context of actual residential environments. The videos did not explicitly depict specific room contexts, allowing participants to imagine their own spatial scenarios. This decision provided flexibility but may have limited the strength of place-specific associations. These limitations inform our recommendations for future research (see Section 5.2).

3.6 Participants

To avoid overrepresentation from a specific academic background, we recruited 56 participants through an online survey platform. Responses were filtered based on completion time, and two

incomplete responses that took less than one minute to complete were excluded. This resulted in a final sample of 54 valid participants (N = 54), yielding a valid response rate of 96%. Among them, 28 identified as male and 26 as female. The age distribution was as follows: 1 participant under 19 years old, 13 aged 20–29, 16 aged 30–39, 14 aged 40–49, and 10 aged 50–59.

4 Results

4.1 Quantitative Evaluation

4.1.1 Product Characteristics

Table 2. Product Characteristics Comparison

Product Characteristic	Difference	Significancy	P
Organic	0.80	Significant	0.0001
Lively	1.52	Significant	< 0.0001
Appealing	0.65	Significant	0.0056
Intelligent	1.28	Significant	< 0.0001
Comfortable	0.35	Not significant	0.0894

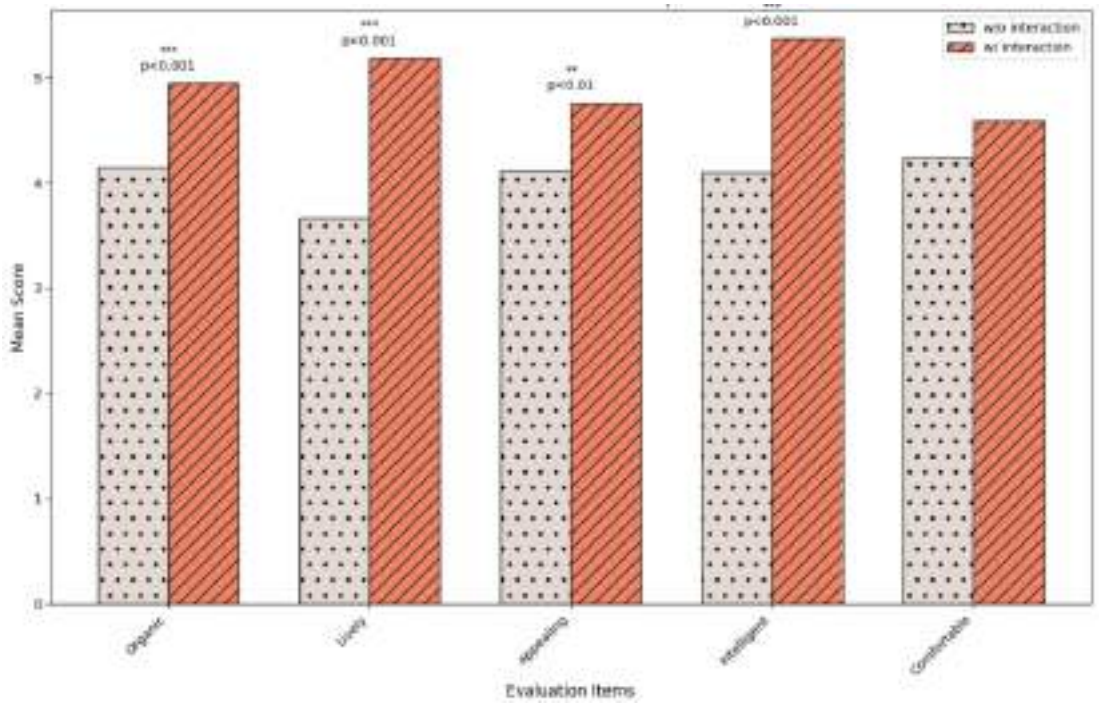

Figure 8. Product characteristics comparison

To test H1, paired samples t-tests were conducted to compare the positive evaluations between the two products, W/O and W [Table 2, Figure 8]. The lighting product with the nodding motion (W) received higher ratings than the product without the movement (W/O). The paired samples t-tests revealed statistically significant differences in four out of five evaluation criteria. Among the interaction evaluation factors, *Organic*, *Lively*, *Appealing*, and *Intelligent* showed statistically

significant differences depending on the presence of interaction. Especially, *Organic*, *Lively*, and *Intelligent* demonstrated high levels of significance ($p < 0.0001$), indicating a clear difference in positive evaluation based on the presence of interaction. The largest difference was found in *Lively* (Difference = 1.52). On the other hand, *Comfortable* did not show a statistically significant difference, suggesting a weaker association between interaction and the perception of comfort. Therefore, Hypothesis 1 is partially supported. While interaction positively influenced perception in some attributes, it did not have the same effect across all aspects.

4.1.2 Placeness Characteristics

Table 3. Placeness Characteristics Comparison

Placeness Characteristic	Difference	Significancy	P
Memorable space	1.54	Significant	< 0.0001
Psychological comfort	0.33	Not significant	0.0599
Attachment to space	0.63	Significant	0.0036
Positive mention to others	1.00	Significant	< 0.0001
Willing to revisit	0.93	Significant	0.0002
Willing to invite others	1.00	Significant	< 0.0001

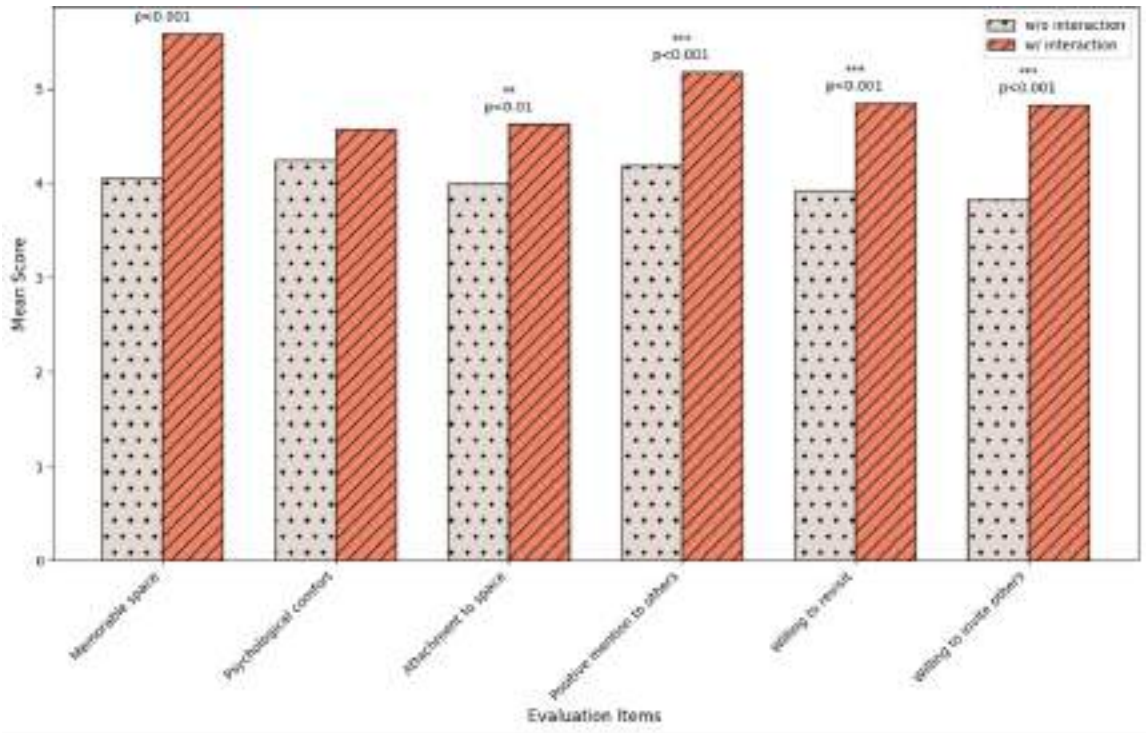

Figure 9. Place Characteristics Comparison

To test H2 and H3, paired samples t-tests were conducted to compare place attachment and behavioral intention between the two product conditions (W/O and W) [Table 3, Figure 9]. Hypothesis 2, which proposes that the product's interaction directly contributes to place attachment(A), was

partially supported. The results showed significant effects in terms of perceiving the space as memorable ($p < 0.0001$) and forming attachment to the place ($p < 0.01$). The greatest difference was observed in *Memorable space* (Difference = 1.54). However, no significant effect was found regarding the perception of psychological comfort ($p > 0.05$), implying that the formation of psychological comfort may not be significantly influenced by the product's interaction alone.

Hypothesis 3, which posits that the product's interaction directly contributes to behavioral intention(I), was fully supported. The findings indicated that the positive emotions formed toward the space due to the product's interaction led to behavioral expressions such as speaking positively about the place, intentions to revisit, and willingness to invite others. All three sub-items related to behavioral intention showed highly significant results ($p < 0.0001$), suggesting that product interaction has a meaningful impact on the formation of place-related behavioral intentions.

4.1.3 Correlation between characteristics and placeness

Table 4. W/O & W interaction: By highest correlation

Correlation of Characteristics and Space Experience		**r**	**p-value**
Because of product W, this space will give me psychological comfort	↔ Comfortable	0.737	< 0.0001
Because of product W, I want to revisit this place	↔ Comfortable	0.694	< 0.0001
Because of product W, this space will give me psychological comfort	↔ Appealing	0.690	< 0.0001
Because of product W, I want to invite others to this space	↔ Comfortable	0.682	< 0.0001
Because of product W, I want to invite others to this space	↔ Appealing	0.670	< 0.0001

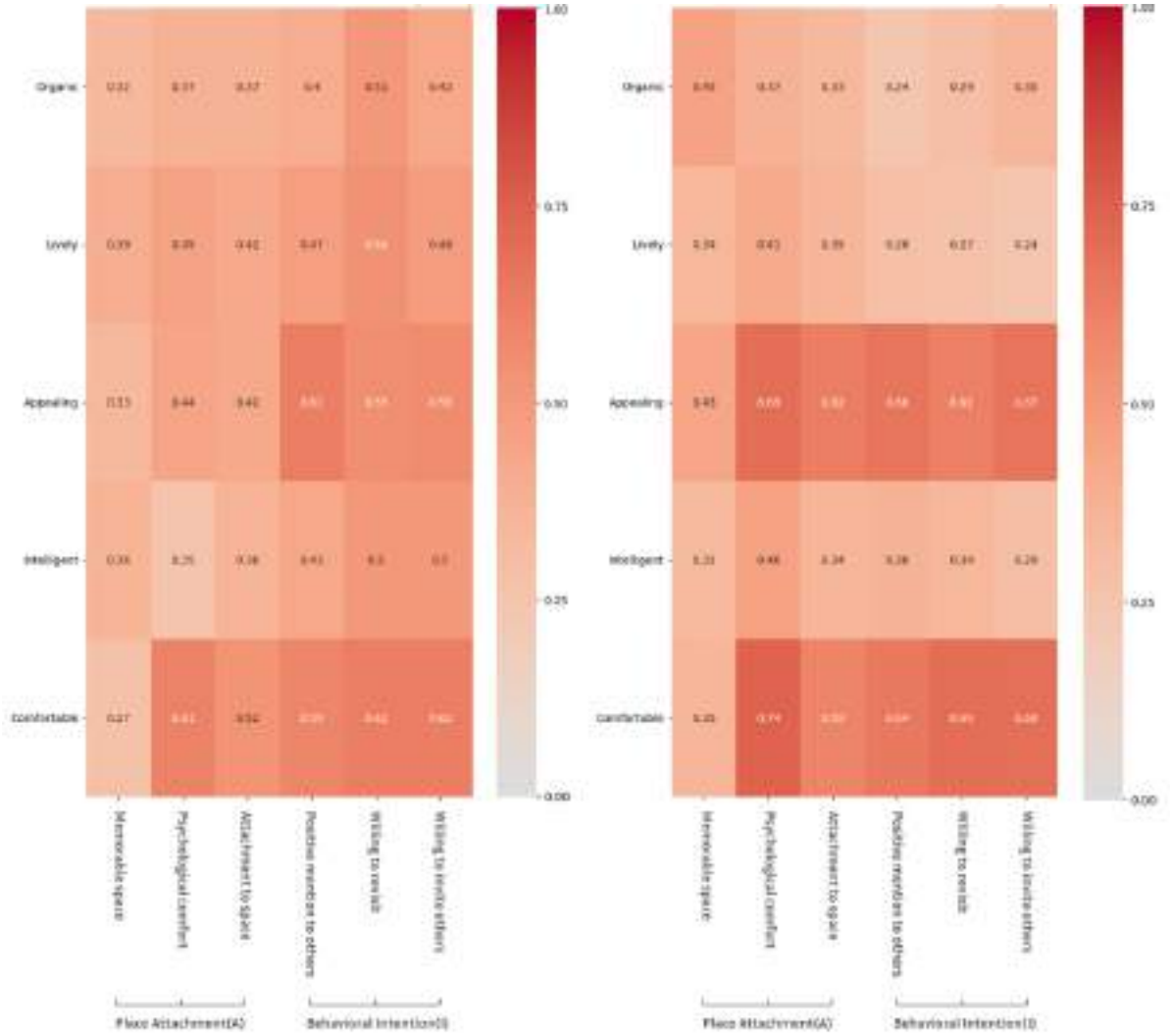

Figure 10. Correlation between characteristics and placeness - Left: Without interaction(W/O) / Right: With Interaction(W)

To examine the relationships between product characteristics and placeness dimensions, Pearson correlation analyses were conducted [Table 4, Figure 10]. The relationships between detailed evaluations of the lighting and the components of placeness were individually analyzed. Among respondents who positively evaluated the interactive lighting (W) as *comfortable*, a strong correlation was found with the perception of psychological comfort within the space. This was the strongest among the 30 identified correlations. According to previous studies, environmental bonding provides attention restoration, emotional recovery, and physical and psychological stability for individuals (Hartig et al., 2001; Kaplan, 1995), which supports the current finding.

Additionally, those who rated the W lighting as *comfortable* also showed a strong correlation with the intention to revisit the space, suggesting an influence on behavioral intention.

Across both W/O and W products, the strongest correlation between detailed lighting evaluations and placeness-related factors was most prominently observed in the W condition. This indicates that when a product's micro-interaction is augmented, it significantly enhances placeness.

4.1.4 Comparison of Preference

Table 5. Largest Differences in 'With Interaction(W) Product' Characteristics Between 'Yes' and 'No' Respondents

Product Characteristic	Difference	Significancy
Appealing	1.88	Significant
Comfortable	1.55	Significant
Organic	0.63	Not significant

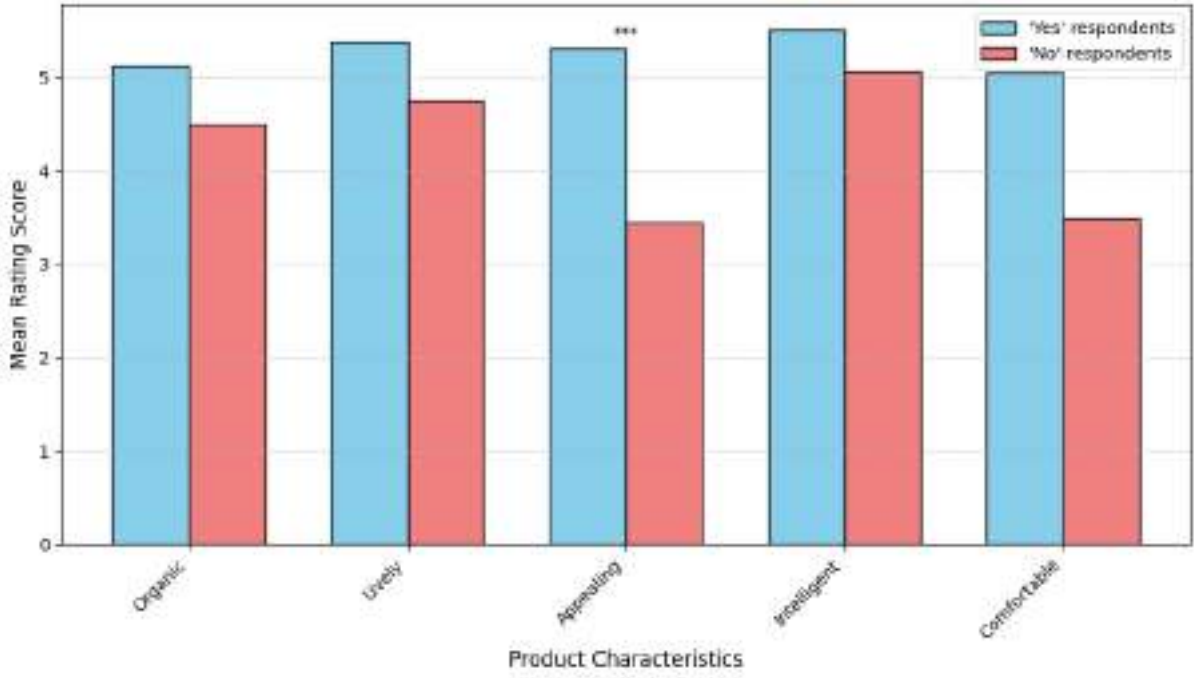

Figure 11. Comparison of 'With Interaction(W) Product' characteristics by preference

Table 6. Largest Differences in 'Placeness' Characteristics Between 'Yes' and 'No' Respondents

Placeness Characteristic	Difference	Significancy
Willing to invite others	2.25	Significant
Attachment to space	1.96	Significant
Psychological comfort	1.79	Significant

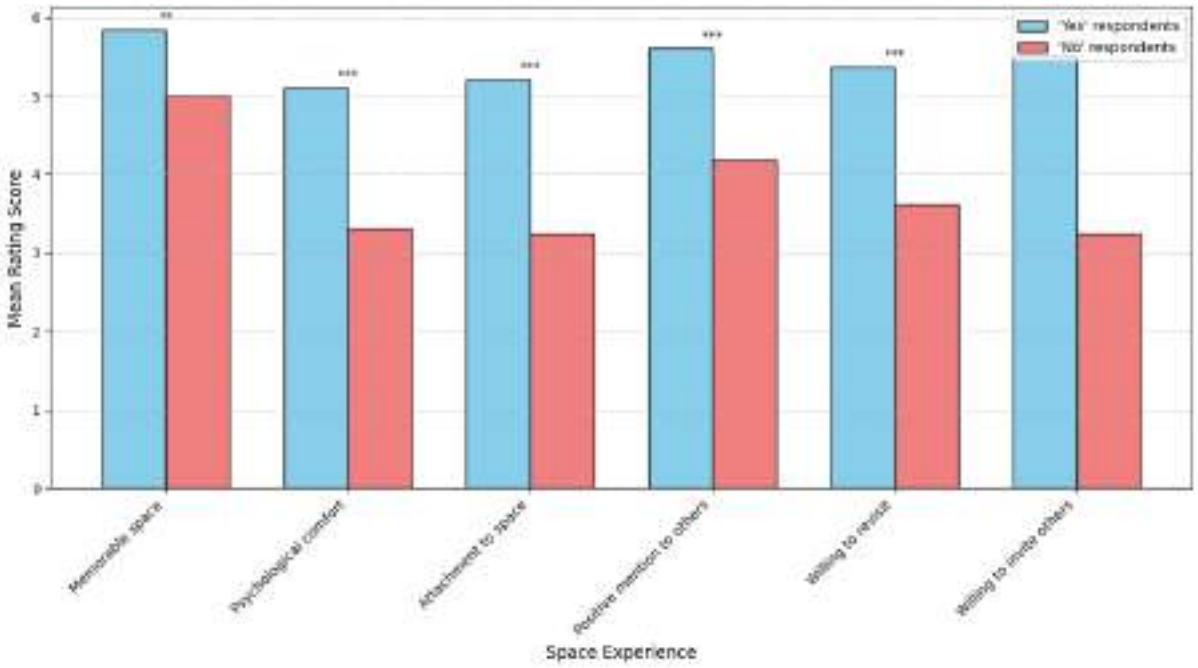

Figure 12. Comparison of 'Placeness' characteristics by preference

Among the participants, 70.4% responded positively, indicating that they would like to place the W lighting fixture, which incorporates interaction features, in their personal spaces, while 29.6% responded negatively.

N=54, Yes=38, No=16.

[Figures 11 and 12] present the results of the correlation analysis conducted between participants' willingness to place the interactive W lighting fixture in their personal spaces (Yes or No responses) and their evaluations across detailed items related to product interaction (H1) as well as spatiality assessment items (H2 and H3). The total number of participants in this experiment was 54, among which 38 participants (70.4%) responded positively ("Yes"), and 16 participants (29.6%) responded negatively ("No").

The analysis revealed that participants' positive or negative responses toward placing the interactive lighting fixture showed a clear distinction in the "Appealing" item, one of the detailed measures of product preference validated under H1. Participants who expressed a positive intention to install the interactive product in their personal space gave higher ratings for its "Appealing" attribute, whereas those who responded negatively assigned notably lower scores for the same attribute.

Moreover, substantial differences were also observed in the "Comfortable" item between the positive and negative evaluation groups. These findings suggest that perceptions of "Appealing" and "Comfortable" serve as key emotional factors influencing users' willingness to place the interactive lighting product in one's personal space. In contrast, attributes such as "Organic," "Lively," and "Intelligent" did not show statistically significant differences between the two groups.

Regarding the evaluation of spatiality, participants who positively evaluated the placement of the interactive product in their own space also assigned higher scores to the item measuring "Willingness

to Invite Others" to their space. Conversely, participants who evaluated the product negatively provided lower ratings for the same item.

Across all six detailed items constituting the spatiality assessment, positive evaluations of the product consistently demonstrated meaningful associations. These results provide empirical support for a meaningful linkage between spatial perception and positive evaluations of product interaction.

Table 7. 'With Interaction(W) Product' Characteristics Most Strongly Associated with Preference

Product Characteristic	**r**	**p-value**
Appealing	0.658	< 0.0001
Comfortable	0.513	0.0001
Organic	0.252	0.0662
Lively	0.205	0.1364
Intelligent	0.166	0.2314

Table 8. 'Placeness' Characteristics Most Strongly Associated with Preference

Placeness Characteristic	**r**	**p-value**
Willing to invite others	0.685	< 0.0001
Psychological comfort	0.637	< 0.0001
Attachment to space	0.585	< 0.0001
Willing to revisit	0.537	< 0.0001
Positive mention to others	0.485	0.0002
Memorable space	0.356	0.0083

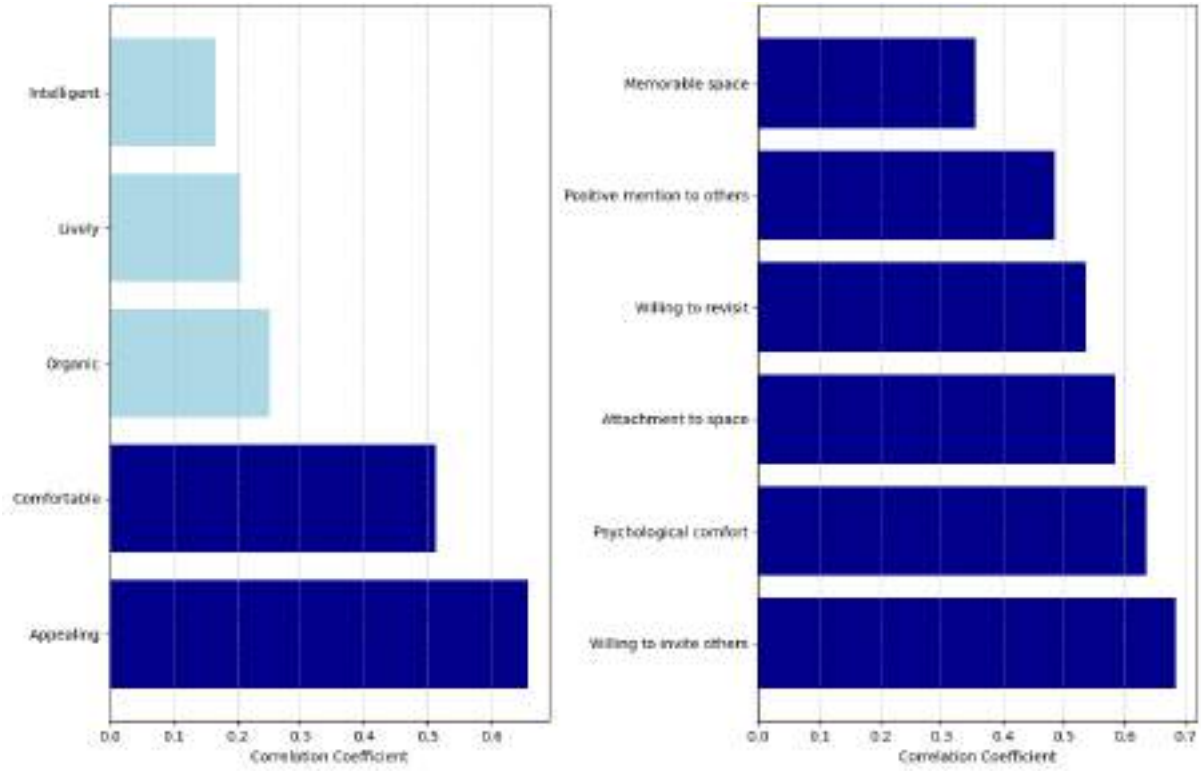

Figure 13. Left: With interaction Product(W) vs Preference / Right: Placeness vs Preference

[Figure 13] presents the final verification of the relationships among product positivity/negativity, and their evaluations of product affect and sense of place. The affective evaluation factors influenced by participants' positive or negative responses toward the product were Appealing and Comfortable.

In contrast, attributes such as "Intelligent," "Lively," and "Organic" did not emerge as critical factors in determining whether participants would choose to place the interactive product in their personal spaces.

The results verified that all items related to place attachment and behavioral intention were influenced by the participants' positive or negative evaluations of the product. Participants who expressed a positive evaluation toward owning the interactive product also exhibited higher scores in place attachment and behavioral intention measures, indicating a stronger tendency to integrate the product into their personal spaces.

These findings highlight that deeply considered planning of both design and interaction—focused on fostering memory and experiential connection from a spatial perspective—can ultimately lead to actual product adoption and ownership. In other words, strengthening the spatial experience through augmentation of interaction and emotional design can directly contribute to consumers' decisions to bring the product into their own living environments.

4.2 Relationship Between Hypotheses and Place Attachment

4.2.1 Structural Equation Model Focused on Place Attachment

In the structural equation model (SEM) of this study, place attachment emerged as a core mediating variable. The analysis revealed that place attachment plays a crucial intermediary role between

product characteristics and behavioral intention, while also exerting the strongest direct effect on user preference.

Key Path Coefficients:

- Product Characteristics → Place Attachment: β = 0.701 (strong positive effect)
- Place Attachment → Behavioral Intention: β = 0.905 (very strong positive effect)
- Place Attachment → Preference: β = 0.621 (moderate to strong positive effect)

These results demonstrate that interactive products (Product B) influence the formation of place attachment, which in turn has a substantial impact on both behavioral intention and preference.

To test the mediating effect, both direct and indirect effects were analyzed:

- Product Characteristics → Behavioral Intention (direct effect): β = 0.629
- Product Characteristics → Place Attachment → Behavioral Intention (indirect effect): β = 0.701 × 0.905 = 0.634
- Total effect: β = 1.264

The indirect effect (0.634) slightly exceeded the direct effect (0.629), indicating that the influence of product characteristics on behavioral intention is more substantial when mediated through place attachment. This finding aligns with Dalavong and Im(2024), who noted that "placeness does not directly affect behavioral intention but rather exerts its influence indirectly through place attachment."

The product characteristics with the greatest influence on place attachment were identified as follows:

Table 9. The product characteristics with the greatest influence on place attachment

Product Characteristic	Path Coefficient with Place Attachment
Appealing	β = 0.682
Comfortable	β = 0.661
Organic	β = 0.432
Lively	β = 0.422
Intelligent	β = 0.432

The attributes “Appealing” and “Comfortable” exhibited the strongest positive effects on the formation of place attachment. This aligns with the results presented in Table 5 and Figure 11, suggesting that emphasizing these two affective traits in product design may be the most effective strategy for enhancing placeness.

4.2.2 Influence of Place Attachment on Behavioral Intention and Preference

Place attachment demonstrated strong effects on both behavioral intention (β = 0.905) and preference (β = 0.621). The particularly high effect on behavioral intention implies that once place attachment is established, users are more likely to revisit, recommend, or invite others to the space.

Moreover, place attachment showed a stronger correlation with preference (β = 0.621) than product characteristics alone (β = 0.482), indicating that emotional connection to place plays a more critical role in influencing users' willingness to adopt and situate the product in their own space.

Among the proposed hypotheses, H2— "Users will associate the lighting interaction with the space, leading to emotional memory formation and comfort—stimulating the affective (A) aspect of placeness"—was partially supported. While the interaction significantly contributed to making the space memorable (Difference = 1.54, $p < 0.0001$) and forming attachment to the space (Difference = 0.63, $p < 0.01$), it did not have a statistically significant effect on the formation of psychological comfort (Difference = 0.33, $p > 0.05$).

4.3 Qualitative Evaluation

In this study, qualitative analysis was conducted on the feedback regarding product interaction, enabling a more in-depth exploration of the underlying rationale behind user evaluations. Furthermore, participants were asked to elaborate on the specific aspects that required improvement, and to explain how such improvements might alter their perception and evaluation of the product.

4.3.1 Flexible Operation of the Product

Participants focused on the human-like characteristics of the product, stating that if the interaction were to become smoother and more flexible, their level of affection toward the product would increase, along with a greater sense of comfort during use. This finding suggests that finer control over the product's motion dynamics could lead to a significantly more positive evaluation. In other words, the precision of interaction appears to form a linear relationship with positive evaluations of the product. Moreover, this finding also implies that achieving a high degree of refined movement could contribute directly to the formation of psychological comfort, which is a fundamental condition for fostering a sense of place.

4.3.2 Product Formation: Approaching as Furniture and Representations of Life

Some participants expressed that they found the lifelike interaction of the product amusing, even describing it directly as being reminiscent of a living creature. This biomorphic perception was considered appealing, particularly for younger demographics, increasing the likelihood of the product being desired as a personal item.

On the other hand, participants who negatively evaluated the product commented that the lack of a sense of friendliness in its design reduced its appeal. However, they also noted that if this aspect were improved, they would be more inclined to place the product in a room where they spend considerable time and thus use it more frequently in their daily lives.

In addition, some participants gave negative feedback regarding the product's color, suggesting that for an interactive product to harmonize naturally within a space, its design should reflect the sensibilities of surrounding furniture.

These observations imply that when considering a space such as a home, harmonizing the tone and manner of the interior design and that of the product design is a critical condition for the successful formation of sense of place. Conversely, if the design language between the product and the spatial environment remains disconnected, it may hinder the development of a strong sense of place.

4.3.3 Installation Location of the Product

Participants also highlighted the importance of the spatial context in which the product would be placed. They suggested that the perceived comfort of a space could be enhanced depending on the product's installation location. Many respondents indicated that non-design elements, aspects such as the smoothness of operation—if further refined—would substantially elevate the sense of comfort and familiarity within the space.

This qualitative investigation allowed for the exploration of user perceptions and ideas that would not have been fully captured through quantitative indicators alone, providing new insights into the interaction between spatial environment and product experience.

5 Conclusion and Limitations

5.1 Conclusion

The structural equation modeling centered on place attachment suggests several key conclusions and practical insights:

1. Place attachment serves as a critical mediating factor linking product interaction with behavioral intention and preference.
2. Enhancing "Appealing" and "Comfortable" features in interactive product design is an effective strategy to foster place attachment
3. Design and interaction should extend beyond individual product experience to promote memory and meaning formation within the spatial environment.
4. Augmenting interactions within a space can extend into users' contextual memory and behavioral responses, thereby making spatially integrated design approaches an effective strategy for influencing behavioral intention.

This place attachment-centered analysis provides empirical support for the core argument of this study: that augmenting product interactions play a meaningful role not only in user-product experience but also in shaping spatial memory and emotional significance.

This study aims to empirically investigate how product interaction facilitates positive user experiences and, in turn, influences the formation of placeness and behavioral intention. To this end, an anthropomorphized product was designed, and both emotional evaluations of the product and placeness assessments were conducted through a combination of quantitative and qualitative analysis.

In the quantitative analysis, Structural Equation Modeling (SEM) was employed to examine the mediating role of place attachment between product characteristics and behavioral intention. Additionally, Pearson correlation analyses were conducted to explore bivariate relationships between specific product characteristics and placeness dimensions. The quantitative results demonstrated that when anthropomorphic interaction was embedded within the product, users tended to evaluate it more positively, particularly regarding the attributes of "Appealing" and "Comfortable." These positive emotional perceptions subsequently acted as significant facilitators in enhancing placeness—especially in strengthening place attachment and behavioral intention toward the space. In contrast,

attributes such as "Organic," "Lively," and "Intelligent" showed relatively minor influence in users' spatial placement decisions.

Moreover, among the placeness evaluation items, factors such as "Willingness to Invite Others," "Psychological Comfort," and "Attachment to the Space" exhibited strong correlations with positive product evaluations. These findings empirically support the idea that a product can go beyond its functional role to offer spatial context to the user, eliciting emotional meaning and behavioral responses related to the place.

The qualitative analysis further revealed that factors such as the refinement of product interactions, a furniture-sensitive design approach, and considerations regarding installation location played significant roles in shaping users' emotional responses. In particular, the product's smooth and flexible movements contributed to the formation of psychological comfort, while the harmonious integration of the product's appearance with the surrounding environment enhanced the overall placeness experience.

This study suggests that product design and interaction planning can extend beyond eliciting positive perceptions of the product itself, contributing to the formation of memory and meaning within the spaces they experience. It highlights the importance of the 'Appealing' and 'Comfortable' attributes as strategic factors for enhancing sense of place, suggesting the need to strategically strengthen emotional elements in future product interaction design. It emphasizes a direction that focuses on augmenting the micro-interactions of conventional products, which often exist solely as functional operations. It highlights a design-thinking approach that transforms functional micro-interactions—such as pressing a switch or turning a doorknob—into expressive micro-interactions. Finally, this study addresses a gap in prior research on the relationship between sense of place and product interaction and suggests that future studies—incorporating diverse product types and spatial contexts—can contribute to the development of a more refined theoretical framework.

5.2 Limitations and Future Directions

This study has several limitations that suggest directions for future research.

5.2.1 Methodological Limitations

Our video-based experimental design (8-second clips) enabled controlled comparison but limited ecological validity. Future research should incorporate field studies with physical prototypes in actual residential settings and longitudinal observations to assess how interactions influence placeness over extended periods. Additionally, our experimental videos did not provide explicit spatial context (e.g., clearly defined entryway vs. living room), which may have weakened place-specific associations. Comparative studies across explicitly defined spatial contexts would strengthen these findings.

5.2.2 RtD Process Scope

While our RtD methodology successfully developed meaningful motion interactions, design iterations focused more rigorously on motion than on tangible elements (color, material, form details). Future RtD processes for interactive products should apply equally rigorous iteration to all design elements, include early contextual testing within intended spatial environments, and develop theoretical frameworks linking material choices to emotional comfort and spatial harmony.

These limitations suggest that effective placeness formation requires both systematic interaction design and holistic consideration of physical form within spatial contexts—a direction that would strengthen both theoretical understanding and practical application of augmented micro-interactions in spatially-situated product design.

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