

From emotional experience to emotional attachment: the proposal of the "attachment layer" in emotional design and its application in biomimetic furniture

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Abstract. In everyday life, people often keep certain objects for many years, even when they are no longer technologically advanced or have lost their functional advantages, simply because these objects have "been with them" through different stages of life. The irreplaceability of such possessions does not stem solely from their practical utility; rather, it arises largely from the emotional memories and psychological bonds accumulated through prolonged interaction and use. As contemporary society faces increasing emotional exhaustion, social pressure, and feelings of loneliness, the demand for emotional support continues to grow. At the same time, the high emotional costs associated with interpersonal relationships have led an increasing number of individuals to seek forms of companionship that are less burdensome and more sustainable. Against this backdrop, the long-term emotional relationship between humans and products, extending beyond the realm of functionality, has gradually emerged as a significant topic in contemporary design research.

Keywords: embodied cognition, gentle restoration, experience design, long-term attachment, emotional design

1. Introduction

Within the framework of the biophilia hypothesis, human beings are considered to possess an innate tendency to seek connections with nature, a disposition that contributes to the maintenance of psychological well-being [1]. This inclination has been consistently reflected throughout the history of furniture design through the adaptation and reinterpretation of natural forms. However, the contemporary urban lifestyle, characterised by a pattern of "high density and low interaction", has gradually weakened interpersonal emotional bonds [2]. Under the combined influences of prolonged emotional labour [3] and the mechanisms described by the conservation of resources theory [4], individuals increasingly seek to minimise emotionally costly social interactions, giving rise to a structural tension between growing emotional needs and declining capacities for social engagement. Against this backdrop, emotional support is gradually shifting from interpersonal relationships to the physical environment, and household products are increasingly expected to fulfil emotional as well as functional roles [5].

Although emotional design theory provides an influential framework for understanding user experience, its three-level model primarily addresses short-term emotional responses and leaves room for further theoretical development regarding long-term emotional relationships. If the establishment of enduring emotional bonds between users and products is overlooked, design is likely to remain focused on immediate sensory stimulation and short-term functional satisfaction. Such an approach encourages the rapid replacement of products, hinders the accumulation of emotional value, and further exacerbates the contemporary pattern of "high turnover and low companionship" in consumer culture.

This study is guided by the following research questions:

Q1: How can emotional design theory be extended to better account for the dimension of long-term emotional relationships?

Q2: In a context where emotional needs are increasing while individuals' social energy is increasingly constrained, how can emotional design establish evaluative criteria centred on emotional relationships, thereby enabling products to evolve from functional objects into long-term companions?

Building upon Norman's theory of emotional design, this study seeks to extend the analytical focus from emotional experience to long-term emotional relationships. Situated within the context of biomimetic furniture design, it proposes a four-layer emotional design evaluation model incorporating an additional attachment layer, with the aim of enriching theoretical discussions of the relational dimension of emotional design. The theoretical significance of this research lies in expanding the analytical object of emotional design from momentary experiences to diachronic relationships. By introducing the attachment layer, the study structurally extends the existing theoretical framework towards a relational perspective while providing a new interpretive approach to biomimetic furniture centred on emotional attachment.

From a practical perspective, the proposed framework offers an operational set of emotional design criteria for contemporary furniture design, assisting designers in creating products that are not only functional and aesthetically appealing but also capable of fostering enduring emotional bonds with users. In particular, it provides a design strategy for delivering gentle, non-intrusive emotional support in response to the emotional needs of contemporary urban populations.

This study takes biomimetic furniture as its primary object of investigation, focusing on the evolution and evaluation of its emotional value. At the theoretical level, it extends the existing emotional design framework by proposing a four-layer evaluative model. At the empirical level, the explanatory power of the framework is examined through analyses of representative biomimetic furniture cases. At the developmental level, the study explores future directions by considering both historical trajectories and contemporary technological conditions. To ensure a systematic progression from theoretical construction to empirical validation, the research adopts a combination of literature review, case study, historical analysis, and trend forecasting.

2. Literature review

2.1. Emotional design theory

The theory of emotional design was systematically developed by the American cognitive psychologist Donald Norman in his seminal work *Emotional Design*. Norman argues that successful design should evoke positive emotional responses at three interconnected levels: the visceral, behavioural, and reflective levels [5]. The visceral level concerns immediate sensory impressions such as visual appearance and tactile qualities; the behavioural level emphasises functionality and the quality of interaction; and the reflective level relates to meaning, cultural values, and self-identity. In furniture design, organic forms, natural materials, and flexible structures can stimulate positive emotional responses across these three levels: the visceral level fosters a

sense of affinity, the behavioural level enhances usability and interaction, and the reflective level embodies the value of harmonious coexistence between humans and nature [6, 7]. Desmet and Hekkert [8] further developed a product experience framework, arguing that product experience encompasses not only aesthetic and sensory dimensions but also experiences of meaning and emotion. Their work provides additional theoretical support for understanding the cultural significance, identity formation, and emotional evaluation associated with the reflective level.

Within the field of furniture design, emotional design theory has been widely applied to both product development and evaluation. Studies have shown that design elements such as form, colour, and material can effectively communicate emotional qualities including safety, pleasure, and relaxation. Biomimetic design occupies a distinctive position within emotional furniture design because of its inherent biophilic qualities [1]. By drawing inspiration from natural forms, structures, and ecological principles, biomimetic furniture can evoke a sense of closeness to nature at the visceral level, optimise functional experiences at the behavioural level, and communicate values of ecological harmony at the reflective level [7]. Desmet and Pohlmeier [9] subsequently proposed the concept of Positive Design, arguing that the objective of design should extend beyond the creation of immediate pleasurable experiences to encompass more enduring dimensions, including subjective well-being, personal significance, and long-term flourishing. This perspective suggests that the focus of emotional design is gradually shifting from short-term emotional responses towards sustained life experiences, offering important theoretical inspiration for extending the study of emotional experience into the domain of emotional relationships.

However, changing social conditions present new challenges for the theoretical framework of emotional design. Contemporary urban populations increasingly confront the dual pressures of interpersonal alienation and emotional labour [3, 10]. On the one hand, individuals seek emotional support; on the other, prolonged emotional exhaustion limits their capacity to maintain socially and emotionally demanding relationships. Consequently, the desired form of emotional support is often one that is low in emotional cost, non-intrusive, and capable of providing gentle, long-term companionship rather than intense social engagement. Norman's three-level model primarily focuses on the elicitation and evaluation of emotional responses, with its analytical emphasis remaining on how users experience products rather than how they develop enduring relationships with them. Recent studies in emotionally sustainable design have further suggested that users' willingness to retain products over time is closely associated with the strength of their emotional attachment. Accordingly, contemporary design research has increasingly turned its attention to the long-term retention value of products and the enduring relationships that can develop between people and the objects they use.

2.2. Attachment theory: an interdisciplinary extension from psychology to design

Attachment theory was originally developed by the British psychologist John Bowlby to explain the emotional bond between infants and their caregivers [11]. The theory is structured around several core concepts. The notion of a secure base refers to the emotional security provided by an attachment figure, enabling individuals to explore the world with confidence. Proximity maintenance describes the tendency to seek closeness to attachment figures. Separation anxiety denotes the distress experienced when separated from an attachment figure, while the safe haven function refers to the tendency to seek comfort and protection from the attachment figure during times of stress or threat [12, 13].

Mary Ainsworth further developed attachment theory through the "Strange Situation" experiments, identifying secure attachment as a pattern in which individuals regard attachment figures as dependable sources of comfort and security, allowing them to return to exploration after receiving reassurance [14]. This

theoretical framework provides valuable insights for understanding the deep emotional bonds that may develop between people and material objects.

Mugge and colleagues [15] introduced attachment theory into the field of product design, defining product attachment as a strong emotional bond between users and products. They argue that such attachment is primarily shaped by three factors: the symbolic significance of the product for personal identity, the pleasurable experiences associated with its use, and the personal memories embedded within it. Schifferstein and Zwartkruis-Pelgrim [16] further identified seven dimensions influencing product attachment: pleasure, self-expression, nostalgia, interdependence, love, care, and memories. Their work provides a more detailed framework for evaluating the emotional value of products.

Chapman [17] introduced the concept of emotional durability, criticising the logic of planned obsolescence and advocating design practices that encourage users to maintain long-term relationships with products. In his view, a product's lifespan depends not only on its physical durability but also on its capacity to sustain emotional engagement over time. This perspective is further reinforced by Belk's theory of the extended self, which proposes that individuals define, express, and extend their identities through their possessions; once a product becomes integrated into a user's self-concept, a strong emotional attachment can emerge [18]. Giaccardi and Redström [19] argue that design research is undergoing a significant shift from concentrating primarily on designed artefacts to examining the continuously evolving relationships between people and things. This study contends that such a transformation indicates that the value of products should not be understood solely in terms of immediate experiences or functional performance, but also in terms of their capacity to support the formation of long-term relationships and to contribute meaningfully to everyday life practices.

2.3. Gentle restoration and embodied support

Loneliness in contemporary society has increasingly become both chronic and concealed in nature. Studies indicate that prolonged solitary living and sustained emotional exhaustion heighten individuals' awareness of emotional deprivation, with subsequent negative effects on subjective well-being and self-identity [20, 21]. At the same time, under conditions of high emotional expenditure, individuals often deliberately avoid socially demanding interactions in order to preserve their limited psychological resources [3, 4, 10]. This self-reinforcing cycle, in which greater loneliness leads to greater social withdrawal [22], suggests that traditional forms of emotional support relying on frequent interpersonal interaction may be ineffective for certain groups, while simultaneously creating a demand for forms of emotional support that are less burdensome and more sustainable.

Research in neuroscience and psychology offers an alternative perspective on this issue. Stephen Porges' Polyvagal Theory proposes that gentle and stable external stimuli, such as warmth, tactile contact, and a sense of enclosure, can activate the parasympathetic nervous system, enabling the body to enter a state of relaxation and perceived safety [23]. Related studies have likewise demonstrated that soft tactile experiences and variations in warmth can effectively alleviate feelings of loneliness and anxiety [24, 25]. Drawing upon these findings, this study defines gentle restoration as a low-energy, non-intrusive, and sustainable mechanism of emotional support. Its essential characteristics are non-verbal communication, low-intensity interaction, and long-term continuity. Against this theoretical background, biomimetic furniture, with its tactile qualities, enveloping forms, and potential for enduring companionship, begins to exhibit emotional values that distinguish it from conventional functional furniture. The mechanism of gentle restoration may be understood as a gradual process through which emotional exhaustion is transformed into a renewed sense of safety and psychological security (see Figure 1).

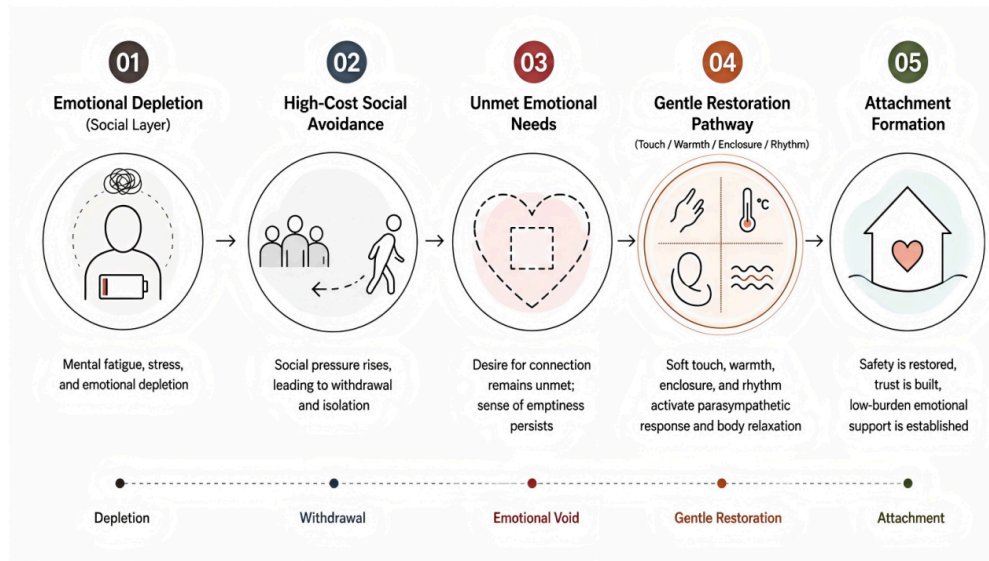


Figure 1. The psychological and physiological mechanism of gentle restoration

2.4. Embodiment deficit: why digital interaction cannot replace physical companionship

Although digital social platforms provide opportunities for communication and self-expression, highly virtualised forms of interaction often intensify the psychological experience of "being seen but not being understood" [26]. One important reason for this limitation is the absence of embodiment in digital communication. According to the theory of embodied cognition, cognition and emotion are not processes confined solely to the brain but emerge through the dynamic interaction between the body and its environment [27, 28]. Pallasmaa [29] further argues that the experience of architecture and material objects is not primarily visual; rather, it is shaped by the combined influences of touch, bodily scale, and the spatial sense of enclosure. This perspective provides an important theoretical foundation for discussing tactile qualities, feelings of containment, and bodily security in furniture design. The concept of embodiment therefore opens new avenues for emotional design in furniture. Through embodied interaction, biomimetic furniture can provide forms of emotional support that are fundamentally different from those offered by digital media, creating experiences of physical presence, sensory engagement, and sustained emotional comfort.

2.5. An integrative gap in existing research

A review of the literature reveals several important gaps. Emotional design theory provides a well-established framework for analysing user experience [5], yet offers only limited explanations of how long-term emotional bonds between users and products are formed. In recent years, design research has increasingly focused on the enduring relationships between people and things. Tonkinwise [30] argues that design should be understood within the context of everyday practices rather than merely as a means of solving isolated product-related problems. This perspective offers important theoretical inspiration for shifting the focus of design research from emotional experience towards relationship building. Attachment theory provides a robust conceptual foundation for understanding deep emotional connections between individuals and material objects [11, 15], but it has not yet been systematically integrated with Norman's emotional design framework. Research on gentle restoration offers a promising approach to supporting individuals experiencing loneliness and emotional exhaustion, although its potential synergy with biomimetic design strategies remains largely unexplored. Studies of embodiment have demonstrated the unique role of physical interaction in the formation of

emotional bonds [24], providing empirical support for design practice. Nevertheless, the existing literature has yet to answer a fundamental question: How can attachment theory be systematically incorporated into the framework of emotional design so as to establish an operational evaluative model capable of assessing and predicting a design's potential to foster long-term emotional attachment?

3. Theoretical framework: from the three levels of emotional design to the attachment layer

3.1. Extending emotional design towards a relational dimension

Norman's three-level model of emotional design—the visceral, behavioural, and reflective levels—provides a classic framework for understanding user experience. The visceral level concerns sensory stimulation and immediate attraction; the behavioural level emphasises usability and the quality of interaction; and the reflective level involves meaning-making, self-identity, and cultural values. However, when the framework is reconsidered from the perspective of relationship development, it becomes apparent that these three levels implicitly describe a process through which the relationship between users and products gradually deepens. The visceral level establishes the desire for approach, the behavioural level fosters dependence through repeated use, and the reflective level creates meaningful personal and cultural associations.

From the perspective of user experience stage theory, the relationship between people and products evolves from momentary encounters into long-term relationships over time [31]. Norman's model therefore successfully captures the progression from attraction to use and ultimately to identification, yet its primary concern remains how users experience products rather than how they develop enduring relationships with them. Building upon this observation, the present study proposes the concept of an attachment layer as an additional dimension that extends emotional design from the domain of experience into the domain of relationships. The attachment layer should not be understood as an entirely separate structure detached from Norman's original framework. Rather, it represents the natural outcome of the continued development and accumulation of the three existing levels of emotional engagement. Its central concern is whether a product can become a medium through which long-term emotional relationships are established and sustained. A psychological perspective is adopted to conceptualise this additional layer because attachment is fundamentally an emotional mechanism governing the relationship between individuals and external objects. Research in psychology suggests that people are more likely to develop enduring emotional bonds with entities capable of providing consistent experiences of security and stable patterns of feedback [11]. Moreover, embodied stimuli such as gentle tactile sensations and feelings of enclosure can further strengthen perceptions of safety and facilitate emotional regulation [23]. At the same time, the theory of embodied cognition argues that emotions themselves emerge through the continuous interaction between the body and its environment [27]. Individuals are therefore more likely to form lasting emotional attachments to objects that can reliably provide security, stability, and bodily comfort. Such attachment arises not only from cognitive appraisal but also from ongoing embodied interaction and the processes of emotional regulation associated with it. From this perspective, psychological theories are valuable not only because they explain why attachment develops, but also because they provide designers with insights into how attachment may be intentionally fostered through design. The introduction of the attachment layer can thus be understood as a theoretical attempt to advance emotional design beyond the analysis of user experience towards the construction of enduring human–product relationships.

3.2. Conceptual definition and structural composition of the attachment layer

The attachment layer refers to the capacity of a design object to transcend its role as a merely functional artefact and, through sustained interaction with the user, develop a long-term emotional bond.

The attachment layer is conceptualised as comprising three interrelated dimensions: security, temporality, and symbiosis (Table 1).

Table 1. Conceptual definition and structural composition of the attachment layer

Dimension	Definition	Design Manifestation	Theoretical Foundation
Security	The extent to which users perceive a product as a reliable source of emotional support that neither judges nor abandons them.	Enveloping forms, stability, gentle feedback, and a non-threatening, pressure-free presence.	Attachment theory [11]; Polyvagal theory [23].
Temporality	The extent to which a product accumulates shared memories through use, allowing wear to become patina and traces of use to become personal narratives.	Materials that age gracefully, surfaces that preserve traces of use, and characteristics that evolve over time.	Emotional durability [17]; extended self [18].
Symbiosis	The extent to which a product establishes reciprocal, low-burden interactions with users, transforming the relationship from one of use to one of coexistence.	Perceptible changes of state, gentle responsiveness, and forms of interaction that invite rather than demand engagement.	Embodied cognition [27]; phenomenology [28].

Among these dimensions, security constitutes the precondition for attachment formation, temporality determines whether the relationship can deepen over time, and symbiosis reflects the transition from a utilitarian interaction to a mode of shared existence between user and product.

Previous studies of product attachment have identified several factors influencing long-term emotional relationships between people and products, including pleasure, self-expression, nostalgia, interdependence, love, care, and memories [16]. Rather than adopting these categories directly, the present study reorganises them according to the underlying logic of relationship formation in design, integrating them into the three broader dimensions of security, temporality, and symbiosis. Specifically, emotional experiences such as pleasure, love, and care are incorporated into the dimension of security, as they primarily concern a product's ability to provide stable, dependable, and low-pressure emotional support. Nostalgia and memories are interpreted as manifestations of relationships accumulating and deepening over time and are therefore subsumed under temporality. Meanwhile, interdependence and self-expression emphasise the relational projection and shared presence that emerge through sustained interaction between users and products and are thus integrated into the dimension of symbiosis. Compared with previous classification systems, this framework places greater emphasis on how these emotional factors operate collectively throughout long-term interaction to facilitate the development of attachment.

Although both the reflective level and the attachment layer involve emotional meaning, they differ fundamentally in their nature. The reflective level concerns the cognitive construction of meaning and can

emerge independently of long-term interaction. For example, a user may identify with a piece of furniture upon first encounter because of its cultural symbolism, aesthetic qualities, or expression of particular values [5, 6]. Such a connection may be described as an interpretative relationship grounded in meaning and identity projection, with the central question being what the product signifies. The attachment layer, by contrast, concerns the formation of relational emotional bonds. Its defining characteristic is not the symbolic meaning represented by the product but whether the product becomes an integral part of the user's lived relationships [11, 15]. Attachment typically develops gradually through repeated use, ongoing interaction, and emotional investment, relying upon the accumulation of time and sustained companionship [17]. The distinctions between the reflective level and the attachment layer can be summarised across three dimensions: temporality, reciprocity, and transcendence of function (Table 2).

Table 2. Comparison between the reflective level and the attachment layer

Dimension	Reflective Level	Attachment Layer
Temporality	May form instantaneously.	Develops through long-term accumulation.
Reciprocity	Primarily a one-way process of cognitive interpretation.	Involves ongoing reciprocal interaction between user and product.
Relation to Function	Based on the recognition of symbolic meaning and values.	Transcends functional utility and centres on companionship.
Core Question	What does this product mean to me?	Can this product accompany me over time?

These distinctions suggest that the reflective level primarily concerns cognitive understanding and symbolic interpretation, whereas the attachment layer emphasises the establishment and maintenance of enduring relational coexistence between users and products.

3.3. Construction of the four-layer emotional design model

Building upon the preceding theoretical discussion, this study proposes a four-layer emotional design model for biomimetic furniture, incorporating the attachment layer as an extension of Norman's original framework (Table 3).

Table 3. The four-layer emotional design model

Layer	Primary Focus	Emotional Depth	Relational Stage
Visceral	Sensory attraction	Immediate emotional response	Attraction
Behavioural	Interactive experience	Sustained satisfaction	Use
Reflective	Meaning construction	Value projection and identity formation	Understanding
Attachment	Emotional bonding	Long-term emotional connection	Coexistence

Within this framework, the visceral and behavioural levels provide the foundation for product experience, while the reflective level deepens the user's understanding through symbolic meaning and personal identification. The attachment layer represents a further stage of relational development, concerned with the formation of enduring emotional bonds between users and products.

The four layers follow a progressive structure. The visceral level determines whether users are initially attracted to a product; the behavioural level influences whether they continue to use it; the reflective level shapes whether they develop a sense of identification with it; and the attachment layer determines whether the product ultimately becomes a lasting companion in their lives. Consequently, the attachment layer should be

understood as a further extension and deepening of the preceding three levels rather than as a replacement for them.

3.4. Case studies

To illustrate the distinctive contribution of the attachment layer, three representative objects are compared using the proposed four-layer framework. The performance of each product across the four dimensions is summarised in Table 4.

Table 4. Comparative analysis of different products within the four-layer model

Product	Visceral Level	Behavioural Level	Reflective Level	Attachment Layer
Smartphone	High (refined industrial design)	Very high (powerful functionality and seamless interaction)	High (symbol of identity and medium of social connection)	Low (dependence is primarily functional rather than emotional; rapid replacement cycles prevent the accumulation of shared memories)
Ming Dynasty wooden chair	High (warm materials and elegant simplicity)	Moderate (satisfies basic seating needs)	High (embodies the values and aesthetics of the literati tradition)	Moderately low (an appreciative and largely one-way relationship, with limited reciprocal interaction)
Plush toy	Moderate (simple and approachable form)	Very low (little practical utility)	Low (limited symbolic or cultural significance)	Very high (provides warmth through physical embrace, encourages emotional projection, and supports long-term companionship)

The comparison demonstrates that strong performance at the visceral, behavioural, and reflective levels does not necessarily lead to the formation of enduring emotional attachment. Although smartphones possess advanced functionality and considerable symbolic value, the relationship between users and these devices is primarily grounded in functional dependence. Plush toys, by contrast, may lack sophisticated functions and profound cultural significance, yet they are capable of fostering stable emotional bonds through tactile comfort, a sense of security, and long-term companionship. It is important to note, however, that the reflective and attachment dimensions associated with plush toys are fundamentally distinct. The reflective level is expressed through the toy's capacity to embody childhood memories or emotional symbolism, addressing the question of "*what the object means*". The attachment layer, in contrast, emerges from the sense of security and emotional reliance developed through sustained companionship, addressing the question of "*whether the object accompanies and supports the user over time*". This distinction suggests that long-term emotional attachment cannot be fully accounted for by the existing levels of emotional design alone and instead requires an independent relational dimension for its explanation.

3.5. Mechanisms of attachment formation in biomimetic design

Biomimetic design is particularly capable of fostering attachment because it naturally evokes associations with living organisms and promotes embodied forms of affinity. According to the biophilia hypothesis, human beings possess an innate tendency to seek connections with living forms and natural environments [1].

Moreover, the curves, textures, and rhythms found in nature can reduce psychological defensiveness and contribute to the development of a sense of safety. However, the mere imitation of natural forms is insufficient to generate enduring attachment relationships. Epley et al. [32] argue that when objects are perceived as possessing agency, animacy, or anthropomorphic qualities, people are more likely to project emotions onto them and establish relational bonds. From this perspective, a genuine attachment layer requires a transition from static forms to dynamic responsiveness, from one-way use to reciprocal interaction, and from momentary experiences to enduring relationships.

The Monstera sofa provides an illustrative example of this process. Its leaf-inspired enveloping structure evokes biophilic responses at the visceral level, creates physical comfort at the behavioural level, and communicates values associated with nature at the reflective level. More importantly, its movable side panels and surrounding configuration create opportunities for sustained interaction and emotional companionship, thereby establishing the conditions necessary for the development of the attachment layer.

3.6. The representativeness and suitability of the Monstera sofa

The experimental prototype adopted in this study was specifically developed within the proposed theoretical framework because it demonstrates, in a relatively complete manner, the progression of the four-layer emotional structure from emotional experience to emotional relationships. Inspired by the leaves of the Monstera plant, the design combines an enveloping morphology with opportunities for user participation and physical transformation, creating conditions that support long-term companionship and the gradual emergence of attachment. Consequently, the Monstera sofa should be understood not only as an example of biomimetic furniture design but also as a representative prototype for examining the validity of the proposed attachment layer. Through the integration of its enveloping structure, leaf-like boundaries, and ergonomic bodily support, the Monstera sofa establishes a mechanism for generating feelings of safety and emotional comfort (see Figure 2).

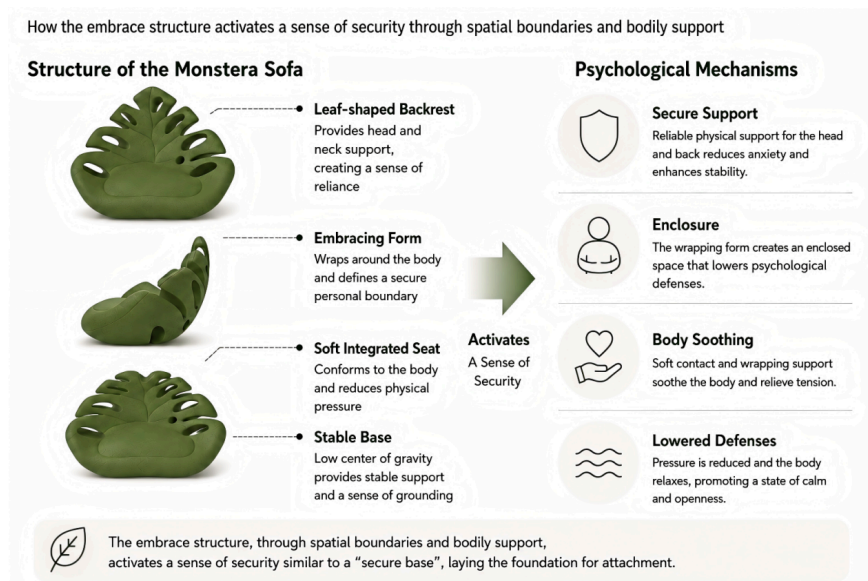


Figure 2. Morphological deconstruction of the Monstera sofa and its mechanism for generating a sense of security

4. Discussion

The purpose of this study is not to challenge or replace Norman's emotional design framework but to address the growing importance of long-term emotional relationships in contemporary design practice. By integrating emotional design theory, attachment theory, research on emotional durability, and studies of embodied cognition, this paper proposes a four-layer emotional design model comprising the visceral, behavioural, reflective, and attachment layers. Furthermore, attachment is conceptualised through three interrelated dimensions: security, temporality, and symbiosis. The analysis suggests that emotional relationships between people and products should not be understood as isolated experiential events but as dynamic processes that gradually emerge and deepen through sustained interaction over time.

Compared with previous studies, which have primarily focused either on emotional responses or on the outcomes of attachment, this research seeks to explain how attachment relationships may be progressively constructed through the design process itself. Consequently, the proposed model serves not only as a theoretical framework for interpretation but also as a practical tool for design analysis and design development. As an evaluative framework, it enables comparisons of different products in terms of their capacity to foster long-term emotional connections. As a design strategy, it assists designers in identifying the key factors likely to facilitate attachment formation during the early stages of concept development.

Norman's three-level model of emotional design [5] provides the foundation for the study of product-related emotions. Its visceral, behavioural, and reflective dimensions effectively explain emotional responses associated with sensory stimulation, interactive experience, and meaning construction. Desmet [6] further argues that product emotions arise not only from functional satisfaction but also from subjective emotional appraisal, while Karapanos et al. [31] demonstrate that user experiences gradually evolve from immediate impressions into enduring relationships over time. Together, these studies provide an important theoretical basis for extending the focus of emotional design from emotional responses to emotional relationships.

Attachment theory [11] and studies of product attachment [15, 16] have established that long-term emotional bonds can develop between people and material objects. Chapman's concept of emotional durability [17] emphasises that a product's longevity depends upon users' willingness to maintain emotional connections with it, while Belk's theory of the extended self [18] suggests that possessions can become integrated into personal identity and autobiographical memory. However, these studies largely concentrate on the outcomes of attachment and provide relatively limited explanations of how attachment may be intentionally fostered through design. Giaccardi and Redström [19] argue that design is increasingly shifting its focus from isolated artefacts towards relational mediators, highlighting the importance of understanding the mechanisms through which relationships are formed. The present study therefore contributes a more structured, design-oriented account of attachment formation.

A fundamental distinction should also be recognised between the reflective level and the attachment layer. Norman [5], Desmet and Hekkert [8] regard the reflective level as a process of cognitive meaning-making grounded in culture, identity, and symbolic interpretation, which may develop independently of prolonged interaction. The attachment layer, by contrast, is conceptually closer to Bowlby's notion of the secure base [11], where the essential issue is not symbolic understanding but relational dependence and emotional security. McGlone et al. [24] and Porges [23] further demonstrate that tactile feedback and low-stimulation environments can activate physiological mechanisms associated with feelings of safety and emotional regulation. Giaccardi and Redström [19] likewise suggest that human-object interactions are evolving towards forms of coexistence rather than simple patterns of use. In this sense, the reflective level and the attachment layer represent two complementary but distinct dimensions of emotional engagement: the former concerns the interpretation of meaning, whereas the latter concerns the formation of enduring relationships.

The comparative case analysis further supports the independence of the attachment layer. By comparing smartphones, traditional wooden chairs, and plush toys, it becomes evident that high functionality or strong cultural significance does not necessarily generate long-term emotional attachment. Norman [5] observes that dependence on smart products primarily arises from the efficiency associated with the behavioural level, whereas Mugge et al. [15] emphasise that attachment requires the gradual accumulation of emotional experiences and personal memories. Turkle's concept of evocative objects [33] similarly suggests that people are more likely to form enduring attachments to objects capable of embodying emotions and providing a sense of companionship. These comparisons offer further evidence that long-term emotional attachment represents a distinct relational phenomenon that cannot be fully explained by the existing three levels of emotional design.

Building upon this framework, the present study further examines the Monstera sofa as a representative case. Wilson's biophilia hypothesis [1] and Benyus' theory of biomimicry [7] both suggest that natural forms possess an inherent capacity to evoke positive emotional responses. Pallasmaa [29] further argues that embodied tactile experiences play a crucial role in the generation of feelings of safety and comfort. Through its enveloping structure and flexible posture, the Monstera sofa translates natural morphology into experiences of security, companionship, and relational potential, demonstrating that the value of biomimetic furniture should extend beyond the visual imitation of nature.

The principal theoretical contribution of this study lies in extending Norman's emotional design framework through the introduction of the attachment layer and in integrating the major determinants of product attachment into three operational dimensions: security, temporality, and symbiosis, thereby establishing a four-layer evaluative framework for biomimetic furniture. Moreover, the proposed model has the potential to be extended beyond biomimetic furniture into other areas of design. Because its primary concern is the development of human-product relationships, it may be applied to research on smart homes, companion robots, wearable technologies, and digital products designed for emotional support. In each of these domains, designers face similar challenges concerning the creation and maintenance of long-term companionship, making the attachment layer and its three dimensions worthy of further validation and development.

In addition, the proposed four-layer model should be understood not only as a theoretical framework but also as a practical tool for design evaluation and strategy development. From a research perspective, it provides a means of comparing different products in terms of their capacity to foster long-term emotional connections. From a practical perspective, it can assist designers during concept generation by identifying the factors most likely to facilitate attachment formation, thereby supporting the development of products intended to encourage enduring companionship.

Several limitations should be acknowledged. First, the present study relies primarily on theoretical argumentation and case analysis and therefore lacks longitudinal empirical evidence. The mechanisms associated with the attachment layer require further validation through long-term user studies. Second, the proposed four-layer model has been developed primarily in the context of physical furniture, and its applicability to digital products and virtual companionship systems remains to be investigated. Finally, cultural backgrounds and patterns of everyday life may significantly influence how individuals understand and experience companionship and attachment. Future research could therefore combine cross-cultural investigations with physiological and behavioural experiments to examine the mechanisms underlying attachment formation more systematically.

5. Conclusion

This study suggests that emotional design can be extended from a framework primarily concerned with emotional responses to one centred on the formation of emotional relationships. Through the analysis of biomimetic furniture, the proposed framework demonstrates its applicability to contemporary design practice. The findings indicate that the attachment layer, structured around the three dimensions of security, temporality, and symbiosis, provides a mechanism through which emotional responses may gradually develop into enduring emotional relationships between users and products. By introducing this additional relational dimension, the study expands the theoretical scope of emotional design while offering a new conceptual and practical approach to the design of products intended to foster long-term emotional attachment and companionship.

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