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Affordance-based design evaluation: Bridging architectural intention and adaptive user behavior

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Affordances—the action possibilities provided by the environment—are a central notion in ecological psychology, offering valuable insights into dynamic user-environment interactions. In recent years, affordance theory has gained traction in architecture and design for its potential to illuminate how users perceive and engage with built environments, informing both design thinking and performance evaluation. Despite this growing interest, its application within architectural design research remains limited. This article introduces an affordance-based evaluation framework developed to analyze how built environments enable or constrain adaptive user behaviors. Grounded in ecological psychology and architectural theory, the framework provides a structured approach for assessing usability, anticipating behavioral variability, and aligning design outcomes with diverse user needs. By explicitly linking architectural intention with situated user-environment interaction, the framework contributes a design-oriented methodology for improving responsiveness, inclusivity, and the adaptive capacity of the built environment throughout its lifecycle.

Keywords: affordances, architectural design, adaptive behavior, design evaluation, user-environment interaction

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1 Introduction

Over the past few decades, researchers have sought to reconcile how designers make relevant decisions during the design process with how users experience and behave in response to the resulting built environments (Schön, 1987/2001; van der Bijl-Brouwer & Dorst, 2017). In architecture, this interaction is fundamental: the discipline is intrinsically concerned with enhancing the

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quality of human experience through spatial design. User behavior in architectural spaces is shaped by the way individuals perceive and engage with the physical and social features of their environment. Despite significant efforts to bridge the gap between design intentions and user behaviors (Gifford, 2007; Lang, 1987), unintended consequences, such as misaligned uses, maladaptive patterns, or interpretive errors, frequently emerge over the life of a building (Newman, 1973). As Hillier (2007) argues, spatial configurations and human activity interact in complex and often unanticipated ways, reinforcing the need for a deeper understanding of how users inhabit and interpret designed spaces.

Traditionally, architectural design methodologies have accounted for user-environment interaction through the lens of function—defining what a space is "for" in terms of deliberate, planned use (Alexander, 1964; Hillier & Hanson, 1989; Lawson, 2007). While this has provided structure to the design process, it has also constrained it. As Alexander (1964) critiques, functionalist thinking tends to oversimplify design problems, which are often vague, evolving, and deeply contextual. Other influential approaches have attempted to bridge the same divide through alternative epistemologies: phenomenological traditions emphasize symbolic and lived experience (Norberg-Schulz, 1968, 1980), behavioral approaches advocate for user-centric design logic (Heimsath, 1977; Hertzberger, 1991), and participatory methods foreground the dialogic and adaptive nature of the design process (Luck, 2007, 2018; Sanoff, 2000). Similarly, strategic and landscape urbanism approaches frame the built environment as a dynamic system that evolves alongside its users (Corner, 1999; Waldheim, 2006). Yet functionalist models continue to fall short in capturing behaviors that fall outside of pre-specified use scenarios, particularly those shaped by emergent needs, evolving routines, or static conditions not explicitly designed for (Poerschke, 2016; Pols, 2015). These models tend to view buildings as instruments for predefined actions, overlooking the ways users interpret, improvise, or adapt design products in everyday life (Brown & Blessing, 2005; Vermaas & Garbacz, 2009). As Hillier (2007) notes, such rigid mappings of space and use risk undermining architecture's responsiveness. Addressing these limitations requires not only new theoretical frameworks but also robust methodological approaches that can systematically evaluate user-environment interactions.

Recent work in design research methodology has emphasized the critical importance of balancing scientific rigor with practical relevance when developing evaluation frameworks (Cash et al., 2022). This methodological foundation is particularly essential for architectural research, where evaluation approaches must capture both the complexity of user behavior and the performance of built environments across diverse contexts and populations. Moreover, recent theoretical work in design studies has begun to address these limitations by proposing anticipatory frameworks that move beyond traditional computational and mechanistic paradigms. Zamenopoulos and Alexiou (2007) argue that design requires the capacity to generate theories and models in anticipation of a correspondence between beliefs and desires, positioning design as fundamentally different from machine-based, evolutionary, or control-oriented approaches. Their anticipatory view of design emphasizes that built environments must be understood as dynamic systems where form, behavior, and meaning co-evolve through user-environment interactions rather than being predetermined by functional specifications. What is needed, then, is a framework that accounts for how built environments not only function but also afford action dynamically, situationally, and relationally.

Affordances, a concept developed in ecological psychology, offer such a framework. Coined by Gibson (1977, 1979/1986) and expanded by scholars like Reed (1996) and Heft (2001), affordances refer to the action possibilities the environment offers relative to an organism's capabilities. For architects and designers, Gibson's insight—"Why has man changed the shapes and substances of his environment?"—is especially resonant. His answer, "To change what it affords him" (Gibson, 1979/1986, p.130) reframes design as the purposeful modification of environmental conditions to create new action possibilities for its users. This positions the act of design as inherently relational, where environmental features derive their meaning through the lens of user capabilities and behaviors. As Pucillo and Cascini (2014) argue, affordances can help designers align environmental attributes with user needs and experiential qualities, fostering environments that resonate both functionally and emotionally.

In recent decades, affordance theory has been adapted to design contexts as an alternative or complement to function-based reasoning (Gaver, 1991; Krippendorff, 1989; Maier & Fadel, 2009; Norman, 1988, 1999; You & Chen, 2007). Whereas functionalist approaches are prescriptive, affordance-based approaches are relational and adaptive. They offer a richer vocabulary for describing how users perceive, engage with, and interpret spatial configurations, whether at the scale of a door handle or a museum gallery (Koutamanis, 2006). Maier et al. (2009) have shown that affordances can serve as a conceptual bridge between product function and user behavior, particularly in architectural applications. Recent contributions have further emphasized that affordances are not only perceived in real-world environments but also in symbolic design representations, allowing designers to anticipate user-environment relations during the conceptual phase (Koutamanis, 2025). Parallel to developments in architecture, product designers are developing affordance-based evaluation methods for assessing user–product interactions that consider user diversity and contextual interpretation, aligning with the need to address behavioral variability in complex environments (Hsiao et al., 2012; Pols, 2012).

By focusing on what environments enable rather than prescribe, affordance theory opens a pathway toward more intuitive, inclusive, and adaptive design. The approach presented in this article builds on this tradition. Rather than positioning affordance-based evaluation in opposition to functionalist methods, we propose it as an extension—one that accommodates spontaneous behavior, emergent use, and behavioral variability. Affordances allow designers to reframe usability not as adherence to intended function, but as the capacity to support diverse and evolving forms of interaction. More than a theoretical proposition, affordance-based evaluation has practical implications: it enables feedback-driven refinement of design, supports inclusive and adaptive use, and better aligns spatial configurations with relational agency.

This article explores the role of affordances as a design-relevant construct that can inform evaluation, guide design reasoning, and improve alignment between architectural intention and user behavior. We focus on three core contributions. First, by cutting across the *objective-subjective dichotomy* that separates form and function in architecture, affordances provide a framework to address the challenges designers face in aligning spatial configurations with intended purposes. Second, by focusing on the information that guides user *agency*, affordances enable the creation of spaces that invite and support certain behaviors. Finally, affordances offer a lens for analyzing how individuals inhabit and interact with their *niches*, deepening our understanding of the dynamic interplay between users and their environments. Building on an integrated ontology that synthesizes ecological psychology and architectural theory, we present an affordance-based evaluation framework designed to systematically assess how built environments facilitate or constrain adaptive user behavior across the building lifecycle.

2 Affordances in the built environment

The notion of affordances, introduced by Gibson (1977, 1979/1986), provides a theoretical foundation for understanding the dynamic interactions between users and their environments. Affordances are actionable properties offered by the environment, shaped by the interplay between environmental features and users' physical and psychological capabilities (Chemero, 2003; Heft, 1988). Gibson (1982) argued that "architecture and design do not have a satisfactory theoretical basis" (p. 413) and suggested that ecological psychology in general and the notion of affordances, in particular, can provide such a basis. He illustrated this point clearly by stating: "A glass wall affords seeing through but not walking through, whereas a cloth curtain affords going through but not seeing through. Architects and designers know such facts, but they lack a theory of affordances to encompass them in a system" (Gibson, 1979/1986, p. 137). Warren (1995) further emphasized that architects should be aware of how to create and communicate affordances within built environments. This perspective underscores the critical role of perception in understanding how users interpret and act upon their surroundings, offering a valuable framework for architectural design.

Affordances have increasingly gained attention in empirical studies by behavioral psychologists and have been adapted into practice by architects, design theorists, and interaction designers. Lang and Moleski (2016) argue that affordances clarify the intricate relationships among the built environment, human activity, and aesthetic judgment. This clarity has encouraged a gradual but meaningful shift within architectural discourse—one that seeks to move beyond static typologies toward more dynamic understandings of spatial use. However, despite this theoretical promise, the application of affordances in architecture remains limited. For example, as the *Avery Index to Architectural Periodicals* indicates, between 2015 and 2023, only 14 articles included the term "affordances," compared to 1135 mentions of "users," highlighting the concept's underutilized status in practice.

Affordances provide an alternative to function-based models by offering a broader and more flexible lens for understanding user-built environment interaction. Whereas functional approaches often hinge on fixed intended uses, affordances accommodate perceptual and behavioral variability (Koutamanis, 2006; Norman, 1988). For instance, Warren (1984) demonstrated that individuals perceive the environment relative to their own body dimensions and capabilities, emphasizing the variability of user experiences. This variability highlights the need for architectural design to accommodate a broad spectrum of user capabilities and perceptual orientations, particularly in spaces that require flexible navigation, layered visibility, or spontaneous adaptation, such as public lobbies, transit hubs, or shared learning environments. The duality of affordances—intertwining environmental features with users' capabilities—illustrates the complex interplay between function and manipulation in design, with cultural contexts often redefining the utility and meaning of built elements (Cosentino, 2021). This dynamic perspective highlights how built environments support both intended and emergent user behaviors, offering a comprehensive lens for design evaluation.

Architecture presents unique challenges for applying affordances due to the wide range of abstraction levels involved. Affordances in architectural design range from individual components, such as door handles, to spatial entities, like bedrooms, and even complex spatial configurations, such as museum exhibition halls. Designers and users often focus on larger configurations involving numerous interrelated objects, requiring simultaneous attention to multiple levels of abstraction (Koutamanis, 2006). For example, while a museum broadly affords functions like shelter, spatial affordances such as accessibility, visibility, and circulation directly shape user behaviors, influencing movement patterns through galleries and engagement with exhibits (Wineman & Peponis, 2010). This multiplicity reflects the inherent complexity of real-world environments, arising from the interplay of diverse users, activities, and spatial features.

Rather than exacerbating complexity, affordances provide a structured framework to navigate and manage it. They enhance transparency in the design process by enabling architects to anticipate how specific decisions influence user behavior, bridging the gap between design intent and actual use. In the best-case scenario, this approach transforms complexity into a manageable and adaptive tool, allowing designers to address the multifaceted needs of users while enhancing the usability and functionality of architectural spaces. Architectural research and practice have historically relied on prototypes and types associated with use patterns and functional requirements, as seen in professional handbooks like Neufert's Architects' Data (2012) and the work of Alexander et al. (1977; 1987). These methods provide valuable foundations but often fail to capture the dynamic processes of user-environment interactions. Affordances move beyond static principles of ergonomics (Galvao & Sato, 2005; Tweed, 2001) to explain discrepancies between design intentions and actual use (Koutamanis, 2006; Mohammadi, Nadimi, & Saghafi, 2017).

The affordance concept is intrinsically tied to specific contexts, referred to as 'situations' in ecological psychology. Situations represent particular relationships among users, environmental conditions, and objects within the environment (Turvey, 1992). These relationships encompass intentional aspects, such as user goals, ongoing actions, and anticipated interactions, as well as physical aspects, including spatial configurations and tangible interactions between users and architectural elements. A situation thus provides the essential contextual backdrop for affordances to emerge, emphasizing that affordances cannot be meaningfully considered independently from their context. Ecologically, situations can be viewed as sets of affordances (Shaw et al., 1982) that exist when relevant compatibilities align users' abilities seamlessly with the environmental opportunities available (Gibson, 1979/1986). By explicitly defining and evaluating architectural situations such as specific spatial layouts, user scenarios, or environmental configurations, architects can more accurately predict and shape user behaviors, experiences, and interactions. Integrating situations explicitly into an affordance-based evaluation framework underscores the necessity of context-specific analysis, enabling designers to proactively support diverse and adaptive behaviors aligned with user intentions and capabilities.

Despite their potential, the application of affordances in architecture remains underexplored, particularly in larger contexts such as urban environments

(Raymond et al., 2017). Rietveld and Kiverstein (2014) emphasize the concept of a ‘landscape of affordances’, which underscores the potential for architectural design to create environments that actively enrich user interactions and experiences. Additionally, the role of sociocultural factors in shaping affordance perception requires further investigation. While ecological descriptions emphasize universality, cultural and social contexts often mediate how users interpret and engage with environmental features (Peponis, 2024). Architecture plays a formative role in structuring the conditions for perception and action, shaping how users inhabit and respond to the built environment. Recognizing this, designers must move beyond static, function-oriented paradigms toward adaptive frameworks that reflect the situated and evolving nature of human behavior. Developing such frameworks is essential for applying affordance theory across diverse and complex architectural contexts, from individual buildings to broader spatial systems (Jelić, 2022).

Therefore, affordances offer a robust framework for bridging the persistent gap between design intention and lived user experience in the built environment. Recent design research demonstrates how aesthetic experience and affordance perception work together, with interaction aesthetics serving as evaluative mechanisms that enhance users’ ability to detect action possibilities in designed artifacts (Xenakis & Arnellos, 2013). By concentrating on the dynamic interplay between users and their environments, affordance theory equips architects with a method for anticipating how spatial conditions may support, constrain, or invite different forms of engagement. As architectural spaces grow increasingly multifunctional and culturally diverse, this perspective becomes essential not only for enhancing usability and adaptability, but also for fostering environments that remain open to interpretation and change. To more fully articulate this potential, the following subsections examine how affordances intersect with foundational architectural concerns—namely, the relationship between form and function, the role of user agency, and the ecological notion of niche.

2.1 *Object and subject/form and function*

The concept of affordance offers a framework for understanding user behaviors in relation to the built environment, transcending the traditional dichotomy between objectivity and subjectivity. As Gibson (1979/1986) explains, “An affordance is neither an objective nor subjective property, or it is both if you like. An affordance cuts across the subjective-objective dichotomy and helps us understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both to the environment and the observer” (p. 129). This duality emphasizes that affordances are relational properties emerging from the interaction between environmental features and user capacities.

This relational understanding finds its philosophical foundation in James's radical empiricism, which positions relations as ontologically primary rather than secondary connections between pre-existing entities. James (1976) argued that "the relations between things, conjunctive as well as disjunctive, are just as much matters of direct particular experience" (p. 226) as the things themselves. Contemporary affect theorists like Barad (2007) and Massumi (2021) extend this relational ontology, with Barad's concept of "intra-action" demonstrating how phenomena emerge through entangled agencies rather than interactions between discrete entities. Applied to architecture, this philosophical grounding suggests that affordances are not properties belonging to built environments or users independently but emerge through specific material-discursive configurations that temporarily stabilize particular action possibilities within relational fields.

The Vitruvian principles—firmitas (durability), utilitas (utility), and venustas (aesthetic)—have long guided architectural design. However, contemporary discourse increasingly advocates for an expanded framework that integrates human activities, behaviors, and performance. This evolution reflects a shift from viewing architecture as static structures to understanding it as dynamic environments that respond to and interact with their occupants. Hensel (2013) underscores the importance of this shift, arguing that architecture must prioritize performance by considering how spaces facilitate human activities and adapt to behavioral patterns. This perspective reinforces the need to design environments that are responsive, adaptive, and attuned to users' needs and actions.

Affordances thus provide a foundation for understanding the congruence between the physical structure of the environment and individual actions. For example, a seat affords sitting due to its surface, height, and ability to support weight, but the perceived utility of the seat depends on the user's needs and intentions (Heft, 1989). This perspective integrates the objective (functional properties of the environment) and subjective (perceived meaning and relevance to the user) dimensions of affordances. Heft's taxonomy of affordances for children's environments, later refined by Kyttä (2002, 2004), demonstrates how specific affordances—such as climbing or grasping—can be systematically evaluated in relation to user needs. However, these approaches often lack the specificity required for guiding architectural design at a niche level, limiting their direct applicability to complex built environments.

Affordances challenge traditional paradigms such as the form-function duality, advocating for a broader framework that encompasses behavior and meaning. Incorporating philosophical insights, affordances in architecture extend beyond objective features to include users' subjective interpretations, which are pivotal to crafting meaningful spatial narratives (Pallasmaa, 2024). Rapoport (1990) expanded this perspective by emphasizing the latent functions of the built environment—meanings and behaviors that emerge through social interaction and individual intentions rather than being immediately evident. He argued that the distinction between function and meaning is misleading, as meaning often constitutes the essential function of the built environment. Integrating layers of meaning into architectural design enriches the interaction between users and spaces, transforming physical environments into platforms for diverse and meaningful engagements. Objects acquire value and significance through their affordances, aligning structural features with user goals and intentions. This interplay between user agency and environmental affordances extends beyond functionalist interpretations to embrace cultural, embodied, and social dimensions that actively shape meaning-making in architectural spaces (Jelić et al., 2016; Robinson, 2021).

The transition from function to affordance represents a significant paradigm shift in architectural thinking. Traditional function-based models assume singular, predetermined uses for built environments, often overlooking the variability and adaptability inherent in user interactions. In contrast, affordances emphasize dynamic relationships between form, behavior, and meaning (Mohammadi, Nadimi, & Saghafi, 2017). Designers must view these relationships as part of a coherent system where individual motivations, social dynamics, and environmental features interact to create meaning. For example, a behavior deemed desirable in one context may be undesirable in another. Consequently, the goal of design is not to prescribe specific actions but to create environments that afford a range of meaningful possibilities aligned with user needs and intentions. Affordances also shift the focus from design intention to potentiality, highlighting the possibilities for action that environments offer. By integrating affordances into the design process, architects can move beyond form-based approaches to consider how physical spaces enable or constrain behaviors. This approach allows for a deeper exploration of human-environment relationships, addressing the motivations and personalities of users to design spaces that are not only functional but also meaningful and adaptable. In this way, affordances provide a robust framework for bridging the gap between the physical attributes of a space and the psychological and social dimensions of its use.

2.2 *Agency*

Agency, grounded in Gibson's (1966, 1979/1986) concept of affordances, emerges from the relational coupling between organisms and their environments rather than residing as a capacity within individuals alone. Agency encapsulates the ongoing co-constitution of perceiver and environment, where both are mutually specified through their relationship rather than existing as separate entities that subsequently interact. In Gibson's framework, affordances invite rather than dictate actions, often guiding behavior without requiring conscious deliberation or explicit decision-making (Withagen et al., 2012). Rather than positioning users as autonomous organisms making choices about passive environments, this ecological view recognizes that everyday behavior emerges through the direct, spatial engagement between organisms and the structured information available in their surroundings. This nuanced understanding of agency underscores the role design plays in structuring the environmental field within which agency emerges, creating conditions for meaningful organism-environment couplings rather than explicitly controlled choice.

In built environments, agency reveals the variability and richness of spatial interactions that emerge. A stairway in a public building, for instance, exists within multiple potential organism-environment relationships: the climber-stairway coupling affords vertical movement, while simultaneously some observers may use the stairway for contemplation of surrounding exhibits, socializers might gather for conversation, and photographers could find unique vantage points for capturing architectural perspectives. These varied interaction patterns illustrate how agency emerges from the multiple ways that environmental features can couple with different organism capabilities and intentions, where meaning is constituted through these ongoing dynamics rather than existing prior to the encounter. This dynamic understanding of agency extends to how organisms select actions within spatial contexts.

Action selection in built environments emerges from ongoing perception-action coupling rather than internal deliberation. This process reflects the dynamic relationship between an organism's movement capabilities and available environmental information. Affordances constitute the interaction possibilities that emerge when environmental features resonate with organism capabilities, creating opportunities for action that are neither purely environmental nor purely organismic but emergent in nature (Barsingerhorn et al., 2013; Pyysiäinen, 2021). Understanding these spatial processes enables architects to design spaces that support diverse forms of user-environment interaction while enhancing the richness of possible engagements.

Extending Gibson's original framework, Withagen et al. (2012) argue that affordances not only present opportunities for action but can also actively invite or even urge specific behaviors. This perspective recognizes that affordances possess an invitational character that emerges from the environmental field between organism and environment, rather than from either entity independently. In design, this means that architects can structure environmental conditions to foster particular spatial interactions while remaining open to emergent possibilities. For instance, the strategic placement of a staircase in a museum creates conditions for multiple simultaneous interactions: movement for circulation, contemplation for reflection, and social gathering for interaction, thereby enriching the action possibilities available within the built environments.

Designing with spatial agency in mind allows architects to structure environmental conditions that support diverse organism-environment interactions, fostering the emergence of meaningful dynamics within built environments. This approach transcends traditional user-centered design by emphasizing the adaptability inherent in spatial systems and emergent interactions—those unexpected relationships that arise when architectural conditions resonate with capabilities in novel ways. These emergent patterns provide critical feedback about the evolving system, revealing new interaction possibilities and offering opportunities for iterative environmental refinement. Designers can support ongoing agency through post-project engagement—providing inhabitants with both physical and conceptual resources to continue adapting their spatial relations after design completion. This approach recognizes that meaningful agency emerges through the ongoing relationship between organisms and environments, rather than being a property solely of individuals or spaces in isolation (Young, 2024). This ecological understanding enables architects to create conditions that can adapt with their occupants, maintaining flexibility over time. Designing for spatial agency thus creates built environments capable of ongoing transformation through the continuous interaction of inhabitants and spatial conditions. By prioritizing this approach, architects can cultivate responsive conditions that support diverse forms of spatial engagement, creating architectures that are inclusive and enriched by interactive multiplicity.

2.3 Niche

Ecological psychology, grounded in Gibson's direct realism, rejects dualistic separations between individuals and their environments. From this ecological viewpoint, human behavior and environmental conditions are interwoven to such an extent that studying them independently becomes impractical (Gibson, 1979/1986). Human perceptual systems have evolved specifically to detect structured information within ecological niches (Gibson, 1966). Central to this perspective is Gibson's notion of the niche, which encapsulates the reciprocal relationship between organisms and their environments. According to Gibson (1979/1986), "A species of animal is said to utilize or occupy a certain niche in the environment. This is not quite the same as the species' habitat; a niche refers more to how an animal lives than to where it lives" (p. 128). Thus, whereas a habitat broadly describes the physical setting or geographic location occupied by an organism, the niche concept emphasizes the specific ways in which individuals or species interact with their surroundings through affordances suited to their unique action capabilities. In architectural terms, a niche therefore describes the dynamic and functional relationship between users and the built environment, highlighting particular opportunities for action that align with user needs, capacities, and behaviors.

Smith and Varzi's (1999) framework identifies six critical features of niches that are particularly relevant to architectural design: (I) Niches exist in physical space and consist of objects with defined physical attributes, such as size, shape, and location. (II) Niches operate as complete systems that achieve specific functions (III). Niches have clear boundaries, distinguishing included objects from those outside the niche (IV). Niches can embed objects or components that belong to separate or higher-level niches, forming hierarchical systems. (V) A niche exists in a specific location based on the functional properties of its components, which support its affordances. (VI) Niches can spatially overlap with others, even when their constituent components differ.

Niches emerge through two complementary processes that shape the dynamic relationship between organisms and their environments. Niche construction describes how organisms actively modify their surroundings to create new affordances, while niche adoption refers to how organisms adapt their behaviors to exploit existing environmental opportunities (Odling-Smee et al., 2003). In architectural contexts, these processes operate recursively: users both shape spaces through their inhabitation patterns and adapt their behaviors to the affordances available in existing built environments. A library reading room, for instance, affords quiet study through its acoustic design and spatial layout (niche adoption), while users simultaneously modify the space through furniture arrangement, territorial behaviors, and the gradual development of informal social protocols that further enhance its study-supporting qualities (niche construction).

This recursive relationship between niche construction and adoption reveals the fundamentally co-evolutionary nature of user-environment systems. Users don't simply occupy pre-designed spaces; they continuously reshape environmental conditions through their presence, activities, and material interventions. Simultaneously, these modified environments structure new possibilities for action, creating feedback loops that drive ongoing niche evolution. A university plaza initially designed for circulation may gradually become a social gathering space as students begin using its steps for seating (construction), which then invites further social behaviors and potentially leads to formal design modifications like additional seating or shade structures (recursive construction). This process illustrates how architectural niches are not static configurations but dynamic assemblages that evolve through sustained user-environment coupling.

Understanding these dual processes enables architects to design for niche evolution rather than fixed functions. Rather than attempting to predetermine all possible uses, architects can create environmental conditions that support both niche adoption—providing clear affordances for intended activities—and niche construction—offering flexibility for user-initiated modifications and emergent uses. This approach recognizes that the most successful architectural spaces often exceed their designers' intentions through users' creative appropriation and gradual environmental modification. By designing with both processes in mind, architects can create environments that maintain their core affordances while remaining open to user-driven transformation and adaptation over time.

Affordances lie at the heart of niche creation and modification, as niches are essentially collections of affordances shaped by objects, spaces, and other entities (Withagen & van Wermeskerken, 2010). Each affordance contributes to the functionality of the niche, influencing user behavior. For instance, a classroom can afford teaching, learning, collaboration, and social interaction depending on its spatial configuration and how users engage with it. Architects often design spaces for specific activities, but these spaces inadvertently create niches that support overlapping and diverse patterns of behavior. Analyzing niches requires a balance between inclusivity and relevance, ensuring that affordances and affordance carriers are meaningful for the intended users (Mohammadi, Pepping et al., 2017). This calls for robust methods that guide niche descriptions to focus on affordances that align with user needs while remaining adaptable to changing contexts. By emphasizing the interplay between affordances, user behavior, and environmental features, the concept of niche provides a powerful framework for advancing architectural design. It enables architects to go beyond prescriptive designs, fostering environments that are user-centered, adaptable, and capable of supporting the dynamic interactions between users and their surroundings. Niche-based approaches hold the potential to reshape how architects conceptualize and evaluate built environments, promoting designs that are both functional and resilient in the face of evolving demands.

3 *Discussion: affordance-based evaluation framework*

This study introduces an affordance-based evaluation framework grounded in ecological psychology and architectural theory. Addressing conceptual limitations identified in traditional functionalist approaches, which tend to be static and prescriptive, the framework explicitly integrates ecological psychology into architectural practice by emphasizing adaptability, user engagement, and responsiveness to evolving behaviors. By leveraging the relational nature of affordances, it translates theoretical insights into practical design reasoning tools and methodologies. In doing so, it operationalizes a user-centered approach to architectural evaluation that effectively aligns spatial intentions with actual user behaviors throughout the design process (Ghaznavi et al., 2025). Affordances thus emerge as design-relevant concepts that can inform architects in the development, evaluation, and refinement of design solutions across different project phases. Specifically, the affordance-based evaluation framework conceptualizes design as the creation of affordance-rich situations rather than the prescription of fixed functions. By focusing on how users perceive, interpret, and act within spatial contexts, the framework supports architects in anticipating emergent user behaviors, adapting design decisions proactively, and ensuring spaces remain flexible and meaningful as user interactions evolve.

The framework emphasizes designing ‘situations’—the contextual conditions that shape user perceptions and behaviors—allowing architects to move beyond mere spatial arrangements toward the active organization of meaningful human experiences. The framework’s integration of empirical methods and feedback loops allows designers to respond intuitively to user-environment dynamics, capturing behavioral insights without relying exclusively on cognitive representations (Pagano et al., 2021). Unlike traditional function-based approaches that assume predefined uses and compliance with fixed technical criteria, this framework acknowledges the adaptability and variability inherent in user interactions with space. It provides a dynamic lens through which design decisions can be evaluated not only in terms of intended function but also in terms of actual use, spontaneity, and experiential quality. In doing so, it supports iterative and reflective design processes, enabling continuous alignment between architectural intention and adaptive user behavior (Fig. 1).

Recent perspectives in architectural design research view design practice as both a subject and a mode of inquiry, aligning with the affordance-based framework’s emphasis on bridging theoretical reflection and situated user interaction (Luck, 2019). An affordance-based analysis provides designers with a holistic approach to identifying and addressing design challenges by

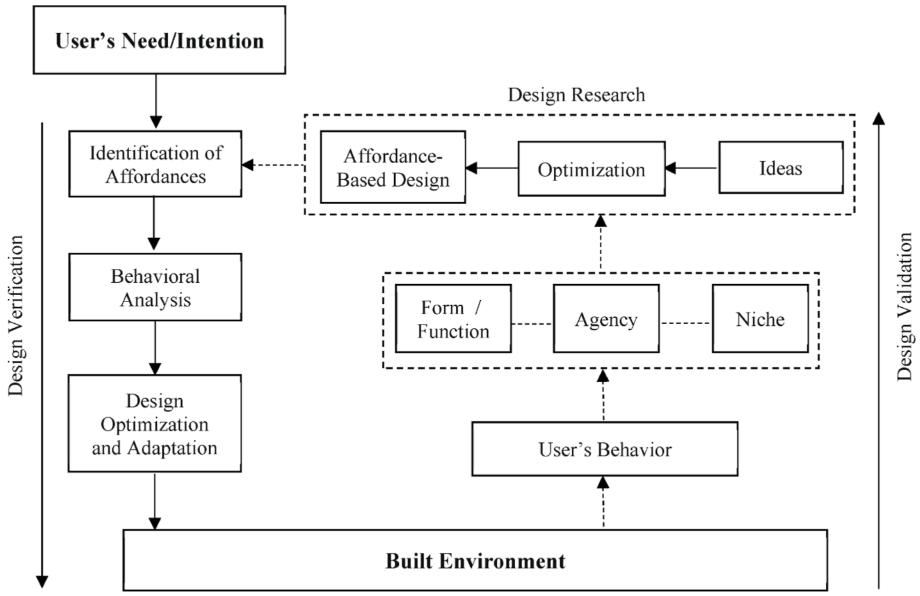

Figure 1 Affordance-based evaluation framework for supporting adaptive user behavior throughout the architectural design process

emphasizing individual user differences, motivations, and behaviors within built environments. As Heft (2022) points out, intentionally disrupting habitual perception-action patterns can stimulate user reflection and innovative behaviors. Leveraging this insight, an affordance-based evaluation framework can guide deliberate design interventions that inspire users to engage with spaces in novel and meaningful ways. However, although affordances provide a powerful conceptual lens for analyzing environmental action possibilities, caution is necessary to avoid stretching the affordance concept to encompass all dimensions of human-environment interactions. Expressive, emotional, and aesthetic experiences, for example, extend beyond purely functional affordances and thus necessitate complementary theoretical frameworks or additional conceptual tools. This multi-theoretical approach aligns with evidence showing that systematic theory development significantly enhances research impact and knowledge advancement in design fields (Cash, 2020). Consequently, integrating affordance theory into architectural practice should explicitly address these broader experiential aspects to achieve a richer, more comprehensive approach to design evaluation.

3.1 Verification and validation as design reasoning tools

At the heart of this framework is the dual process of verification and validation, which together establishes a structured approach to understanding and optimizing user-environment interactions. Verification and validation processes in design, as discussed by Koutamanis (2023), benefit from detailed analyses of affordance relationships and their connection to design performance. The emphasis on explicit protocols and interfaces offers a robust methodology for ensuring that built environments align with user needs effectively. Verification ensures that a built environment's features meet predefined technical and functional requirements, such as door widths adhering to accessibility standards for wheelchair users. However, while verification ensures compliance with specific criteria, it falls short of evaluating how these features collectively support a user's overall experience.

Validation addresses this gap by examining how affordances align with user needs and goals, providing a bottom-up perspective that holistically considers user behavior (Gero & Kannengiesser, 2004; Maropoulos & Ceglarek, 2010). For example, validation not only assesses whether a staircase meets structural and dimensional requirements but also evaluates how it accommodates diverse uses, such as resting, gathering, or engaging with architectural aesthetics. This integration moves beyond prescriptive design practices, highlighting the critical role of affordances in mediating the relationship between the built environment and user behavior. The framework's emphasis on adaptability and user engagement aligns with recent advances in affordance theory, including Koutamanis (2025), who argues that affordances in design are not only perceived in physical spaces but also in abstract design representations, such as drawings and models. This expands the scope of affordance-based reasoning beyond use into the domain of design conception.

Together, verification and validation constitute a comprehensive approach for aligning architectural design with occupants' dynamic and evolving needs. Verification ensures fundamental functional requirements are satisfied, while validation examines broader experiential and behavioral outcomes. This iterative methodology prioritizes adaptability through continuous feedback loops, allowing architects to refine designs based on emergent and situated user behaviors (Ding, 2023). Predictive tools and thought experiments further bridge speculative design concepts with practical outcomes, proactively anticipating user needs and creating responsive, flexible environments aligned with affordance-based principles. This anticipatory capacity reflects a fundamental shift in design thinking—the ability to generate solutions in anticipation of emergent correspondences between design intentions and user experiences, rather than relying on predetermined functional requirements (Heintz, 2006; Zamenopoulos & Alexiou, 2007).

3.2 *Feedback loops and emergent behavior*

User interactions with built environments provide critical behavioral insights that inform iterative refinements across multiple levels, revealing emergent affordances and evolving patterns of use. These insights are not limited to post-occupancy phases; they begin as early as the initial stages of design. Research shows that early conversations between architects and users play a formative role in shaping how functional and experiential qualities of spaces are imagined. Through these dialogues, design intentions are socially constructed, and perceived affordances are co-developed even before any formal drawings are produced (Luck & McDonnell, 2006). Integrating these dialogic and behavioral feedback mechanisms into the design process is essential for fostering environments that are responsive and adaptable to user needs (Mallory-Hill et al., 2012). For instance, a central stairway in a museum, originally conceived as a circulation element, may later be perceived by users as a space for social interaction or quiet observation—uses that extend beyond the architect's initial intent (Koutamanis, 2024). Discovering and acknowledging such emergent behaviors enhances usability and satisfaction by aligning spatial functions with actual user experiences.

Furthermore, neuroscientific evidence reinforces the dynamic nature of affordance perception. Hilton et al. (2025) demonstrated through EEG studies that affordance perception is neurologically integrated with users' intentions for action. Their findings revealed distinct cortical responses when users evaluated spaces with a specific action in mind, as opposed to passive aesthetic assessments. This evidence underscores that affordances are not static properties of space but contextually situated and cognitively mediated phenomena.

Taken together, these behavioral and neuroscientific insights reinforce the theoretical foundation of the affordance-based evaluation framework. They highlight the importance of feedback loops—not merely as post-occupancy evaluation tools, but as continuous, embedded mechanisms in the design process that help architects anticipate and support adaptive user behavior.

3.3 *Affordances across the design lifecycle*

The adaptability of affordances within this framework underscores their utility in both pre-and post-occupancy evaluations (Hardy et al., 2018; Preiser et al., 2017). In pre-occupancy evaluations, affordances can guide designers in anticipating potential uses and misuses of spaces, leading to more inclusive and versatile environments. For example, by analyzing the action possibilities afforded by a public plaza, designers can predict how diverse user groups might interact with its features, from seating arrangements to circulation pathways. Recent empirical work validates this approach: Karadağ (2025) demonstrated how immersive virtual environments can effectively capture user-environment interactions during wayfinding tasks, revealing how specific environmental features—wall-mounted versus floor-integrated signage—differentially influenced navigation performance, spatial confidence, and user satisfaction. This study exemplifies how affordance-based evaluation frameworks can inform iterative design decisions by systematically analyzing how environmental modifications alter the action possibilities available to users. In post-occupancy evaluations, the framework provides a mechanism for systematically assessing how well design elements align with user needs over time, revealing opportunities for refinement and enhancement. Affordance-based evaluations are particularly effective in identifying how environmental features facilitate or constrain intended behaviors, ensuring that design adjustments align with evolving user requirements (Bardenhagen & Rodiek, 2016).

By emphasizing adaptability and user engagement, the affordance-based evaluation framework challenges architects to rethink traditional design methodologies. It shifts the focus from static functions to dynamic interactions, fostering environments that are not only functional but also enriching and responsive (Pucillo & Cascini, 2014; Tweed, 2016). This approach situates affordances as central to the design process, enabling architects to anticipate and accommodate a diverse range of behaviors. An affordance-based approach gains depth when considering the atmospheric and emotive dimensions of architectural design, which shape not only usability but also the experiential quality of spaces (Condia et al., 2020). The result is a more user-centric architecture that evolves alongside its occupants, supporting continuous adaptation and enhancing both usability and satisfaction throughout the lifecycle of the built environment. By doing so, designers can create environments that not only meet functional requirements but also invite a range of behaviors, fostering user engagement and satisfaction. This approach provides a pathway for future research, suggesting new directions for integrating affordances into architectural theory and practice, with the potential to transform how designers conceive and evaluate built environments.

4 Conclusion and future work

This article has presented an affordance-based evaluation framework that integrates ecological psychology into the design and evaluation of built environments. By focusing on the dynamic relationship between users and the affordances of architectural spaces, the framework bridges the gap between design intentions and actual user behaviors. It provides a robust methodology for enhancing usability, functionality, and adaptability in architectural design, ensuring that built environments are not only purpose-driven but also responsive to the diverse and evolving ways in which users interact with their surroundings. The framework's key contribution lies in its potential to transform the design process by prioritizing user engagement, adaptability, and behavioral feedback. By leveraging affordances, architects can achieve a more nuanced understanding of how spaces are used, enabling the creation of environments that accommodate a range of behaviors rather than prescribing rigid functions. This perspective fosters a more flexible, user-centered design approach, aligning architectural practices with the dynamic needs of users throughout the lifecycle of a built environment.

While this article presents a theoretically grounded affordance-based evaluation framework, several important limitations must be acknowledged. The framework remains conceptual and has not yet been empirically validated through systematic application in real architectural projects, meaning its practical effectiveness in improving design outcomes remains speculative. Additionally, affordance theory itself has inherent boundaries—expressive, symbolic, and aesthetic experiences often exceed purely functional affordances, requiring complementary theoretical frameworks for comprehensive architectural evaluation. The framework also lacks specific operational protocols for identifying affordances, measuring their effectiveness, or standardizing applications across different contexts, presenting significant methodological challenges for practical implementation. These limitations suggest that affordance-based evaluation should be understood as one valuable tool within a broader methodological toolkit rather than a complete solution to architectural design evaluation.

Future research should aim to validate this framework further through its application in diverse architectural contexts. Conducting case studies investigating user behavior in real-world settings will provide essential insights into its practical implementation and effectiveness. Moreover, developing tools and methodologies for systematically integrating affordances into the design process will be critical for improving the usability and performance of built environments. Such advancements can guide architects in designing built environments that are not only adaptable and user-centric but also capable of evolving to meet the changing needs and goals of their occupants. Ultimately, this affordance-based approach offers a pathway toward creating more resilient, inclusive, and behavior-responsive environments.

CRediT authorship contribution statement

Mohsen Mohammadi: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Alexander Koutamanis:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Investigation, Funding acquisition, Conceptualization.

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

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Data availability

No data was used for the research described in the article.

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