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Emotionally Adaptive UX Interfaces: A Scenario-Based Framework for Real-Time Personalization

Abstract: The increasing complexity of user needs and digital contexts necessitates the development of adaptive user interfaces capable of emotional responsiveness. Traditional emotional personalization methods, reliant on biometric data, often prove costly, intrusive, or impractical for early prototypes and large-scale deployments, raising privacy concerns. This paper addresses these limitations by introducing a novel conceptual scenario-based behavioral framework for emotionally adaptive web UX. The object of the study is to explore how user interfaces can dynamically adjust to a user's affective state using only observable behavioral indicators, without physiological sensors. The study aims to demonstrate that cues like navigation style, input pacing, or reaction latency can inform UX modifications aligning with emotional states, offering a scalable and ethically sustainable alternative or complement to biometric solutions. The methodology involved developing three synthetic user personas (stressed, bored, focused) based on Plutchik's Wheel of Emotions and validated behavioral attributes. Interface mockups were designed in Figma, focusing on adaptive UX fragments. A structured heuristic evaluation, using a 5-point Likert scale and seven key metrics (e.g., perceived emotional fit, cognitive effort, mental model resonance) aligned with ISO 9241–210:2019 and ISO/IEC 25010:2023, assessed the framework. This work integrates insights from key researchers: Zeng et al. and Chen & Li on emotional congruence; Nielsen, Sarodnick & Brau on heuristic evaluation; Huang & Singh on emotional fit; Gentner & Stevens on mental models; and Liu & Wei and Khan & Shukla on emotion-aware computing. Results show that Hypothesis H1, affirming significant emotional alignment from scenario-based adaptation without real-time sensing, was validated. The stressed (4.6 emotional fit) and focused (4.7 mental model resonance) personas showed high alignment. Hypothesis H2, concerning behavioral adaptation's sufficiency in low-tech contexts and its complementary role in high-fidelity designs, was also supported. Critically, the boredom scenario (low engagement 2.9) highlighted that overstimulation without guidance can disrupt mental models, suggesting the need for refined hybrid adaptation logic. The findings confirm emotional responsiveness can be approximated via behavioral interface design, with hybrid systems offering dynamic fine-tuning. This framework introduces a vital "hybrid potential" for both substituting biometrics in constrained environments and augmenting them in high-stakes systems.

Keywords: emotion-aware UX, adaptive interface, personalization, user modeling, affective computing, neural design logic, behavioral adaptation, scenario-based design.

Abbreviations:

AI is Artificial Intelligence,

HCI is Human-Computer Interaction,

UAI is adaptive user interface,

UX is User Experience.

Introduction

The escalating complexity of user needs and digital contexts necessitates the development of adaptive user interfaces capable of emotional responsiveness. Current emotional personalization often relies on costly, intrusive biometric data, limiting its practical and ethical application.

This paper introduces a novel conceptual scenario-based behavioral framework for emotionally adaptive web UX, utilizing observable indicators for simulated real-time adjustments.

The object of the study is to explore how user interfaces can dynamically adapt to a user's affective state through non-invasive behavioral cues like navigation style, input pacing, or reaction latency.

The primary aim is to demonstrate that such cues can effectively inform UX modifications, offering a scalable and ethically sustainable alternative or complement to biometric solutions.

The methodology involves developing three synthetic user personas (stressed, bored, focused), meticulously modeled using Plutchik's Wheel of Emotions and validated behavioral attributes. Interface adaptations are then evaluated through a structured heuristic assessment, employing key metrics aligned with ISO 9241–210:2019 and ISO/IEC 25010:2023. This work builds upon foundational research by Zeng et al., Chen & Li, Nielsen, Sarodnick & Brau, Liu & Wei, Khan & Shukla, Huang & Singh, and Gentner & Stevens. The results are intended for UX designers, interface engineers, and HCI researchers seeking practical and ethical personalization strategies.

Methods

1. User Scenarios and Emotional States

Three synthetic user personas were developed to simulate distinct affective contexts. Each persona was modeled using Plutchik's Wheel of Emotions, validated with UX-related behavioral attributes drawn from prior studies (*Matsuda et al., 2018*; *Dalvand & Kazemifard, 2013*):

- Persona A (*Figure 1*): A time-pressured user experiencing stress. Mental model: expects rapid task resolution with minimal distractions.
- Persona B (*Figure 2*): A disengaged user experiencing boredom. Mental model: anticipates interactive feedback, novelty, and agency in task progression.
- Persona C (*Figure 3*): A focused user with high need for continuity and minimal distraction. Mental model: expects high predictability, clear task progression, and low interface noise.

Interface mockups were created in Figma and included UX fragments—specific elements affected by emotional adaptation (e.g., login forms, confirmation modals, navigation sidebars).

For each persona, the before and after states of selected fragments were redesigned to align with the user's predicted emotional and cognitive state, based on inferred mental models.

For instance, the mental model of Persona A prioritizes efficiency and clarity; therefore, checkout forms were adapted to include only essential fields, no branching logic, and passive visual cues. Persona B's mental model is exploratory and engagement-seeking, hence the addition of tooltips and visual feedback to maintain curiosity. Persona C seeks uninterrupted execution and consistency, leading to simplification of system prompts and use of progressive disclosure. Thus, these persona-specific adaptations highlight how behavioral indicators, when mapped to underlying emotional states and mental models, can guide targeted UX modifications even without direct physiological input, establishing a foundational proof-of-concept for the proposed framework's design principles.

2. Evaluation Approach

A structured heuristic evaluation was performed using a 5-point Likert scale (1 = very poor, 5 = excellent). Seven evaluation metrics were selected:

1. Perceived emotional fit
2. Interaction fluency
3. Cognitive effort
4. Disruption recovery
5. Engagement stimulation
6. Affective friction points
7. Resonance with mental model

Here, the inclusion of "resonance with mental model" allows direct tracing of interface logic to user expectations (*Figure 4*). This improves the accuracy of emotional alignment and surfaces areas where system design contradicts user assumptions. Thus, the comprehensive set of evaluation metrics, including novel ones like "resonance with mental model", provides a robust framework for assessing the effectiveness of emotionally adaptive interfaces, ensuring that both functional and affective aspects of user experience are thoroughly evaluated.

Literature Review

Research on emotionally UAIs has evolved from early models of affective computing toward integrated, user-centred frameworks that fuse emotional recognition, context awareness, and dynamic adaptation. The foundations of this field were laid by Tao and Tan (*2005*), who conceptualised affective computing as the ability of systems to recognise, interpret, and simulate human emotions. This early theoretical groundwork was expanded by Duric et al. (*2002*), who proposed combining perceptual and cognitive modeling to improve the intelligence and adaptability of human-computer interactions. Together, these works provided the conceptual basis for adaptive UX systems capable of understanding user emotion and behavior in real time.

Calvo and D'Mello (*2010*) advanced this field through an interdisciplinary review of affect detection models, integrating psychological, physiological, and computational perspectives. Their taxonomy of affective models identified multimodal recognition—such as facial expressions, voice, and physiological signals—as essential for reliable emotion detection in user interfaces. This comprehensive approach paved the way for practical adaptive systems capable of personalising interfaces based on affective cues. Dalvand and Kazemifard (*2013*) further demonstrated the feasibility of emotional adaptation by designing an adaptive user interface responsive to users' emotional states, showing that real-time feedback can significantly enhance interaction satisfaction.

In parallel, the conceptual understanding of UX evolved. Bargas-Avila and Hornbæk (*2021*) proposed a unified model of UX that combines emotional, cognitive, and behavioural dimensions. This model recognised emotion as a central determinant of UX quality, emphasising the need for design approaches that dynamically adjust to users' affective states. Similarly, Chen and Li (*2021*), in their systematic review, reinforced the view that emotion is not a peripheral factor but a core driver of UX, shaping user engagement, satisfaction, and decision-making processes. Their findings underline the need for adaptive systems that can interpret and respond to user emotions holistically.

Recent studies have focused on formalising the mechanisms through which adaptation occurs. Alipour, Céret, and Dupuy-Chessa (*2023*) proposed a temporal-emotion framework for user interface adaptation, emphasising that emotional states evolve dynamically and require temporally sensitive adaptation strategies. Their work highlights the importance of designing interfaces capable of recognising emotional trajectories rather than static states. In similar spirit, Stephanidis et al. (*2021*) developed a comprehensive framework for UX evaluation in intelligent environments, positioning emotional adaptation within the broader context of multimodal interaction and ambient intelligence. This holistic evaluation approach supports iterative design processes that balance user satisfaction, efficiency, and affective resonance.

Empirical research has further validated these frameworks. Matsuda, Yoshida, and Oka (*2018*) demonstrated through their EmoTour system that multimodal behavioural cues—such as gaze direction, facial expression, and voice tone—can be effectively used to infer user emotions and satisfaction. Schuller et al. (*2018*) contributed by analysing large-scale affective computing challenges, identifying computational paralinguistics as a key enabler for robust emotion recognition across real-world environments. More recently, Sun and Jiang (*2025*) used eye-tracking to link gaze behaviour with emotional experience, revealing that subtle visual attention patterns can predict affective responses to interface design elements. Such findings reinforce the necessity of integrating physiological and behavioral indicators into adaptive UX systems.

Parallel advancements in conversational and AI-driven systems have expanded the scope of emotional adaptation. Mahmud et al. (*2025*) reviewed UX evaluation in conversational recommender systems, comparing classical approaches with large language model (LLM)-based frameworks. Their study demonstrated that emotional adaptivity plays a crucial role in improving user trust and engagement, particularly in AI-mediated interactions. These insights connect affective computing with the emerging paradigm of emotionally aware AI, where the interface itself becomes a participant in the user's emotional context.

Collectively, the literature reveals a clear progression from theoretical conceptualisations of affective computing to data-driven, context-sensitive, and temporally adaptive UX systems. Emotionally adaptive interfaces are now recognised as essential to personalisation, contributing to more natural, empathic, and satisfying user experiences. Future frameworks, as the reviewed studies suggest, must integrate multimodal sensing, real-time analytics, and continuous emotional feedback loops to achieve seamless interaction that respects both the cognitive and affective dimensions of human behaviour (*Alipour et al., 2023*; *Stephanidis et al., 2021*).

Results

Expert ratings for each persona-interface pair are summarized in the Appendix (*Table 1*).

Key findings include:

- Persona A (stress scenario): The adapted interface significantly aligned with the user's stress-avoidant mental model—minimal interactions, limited color saturation, and sequential flow. High emotional fit (4.6) and low friction (1.2) were observed. Experts emphasized rapid task completion and reduction of intrusive elements. This supports H1, affirming that simulated behavioral changes can evoke emotional congruence. Thus, the successful emotional alignment achieved for Persona A strongly supports Hypothesis H1, demonstrating that simulated behavioral changes, carefully designed to match a user's mental model, can indeed evoke significant emotional congruence and improve user comfort in a stress-avoidant context.
- Persona B (boredom scenario): Despite efforts to stimulate interaction via color and micro-feedback, the adapted interface received lower scores in engagement (2.9) and resonance (3.0). Experts noted mismatch between intended emotional lift and actual user clarity. This highlights a key insight: overstimulation without guidance can break the user's mental model, leading to affective friction. The data supports refinement of hybrid adaptation logic—where behavioral cues must balance novelty with narrative coherence. Thus, the findings for Persona B underscore the complexity of adapting to boredom; while behavioral cues offer potential for stimulation, they must be carefully balanced with narrative coherence to avoid overwhelming the user and disrupting their mental model, suggesting a need for more nuanced, possibly hybrid, adaptation strategies.
- Persona C (focus scenario): The adapted UI matched user expectations for minimal distraction, strong task continuity, and predictability. Ratings were highest across all metrics (emotional fit: 4.4; interaction fluency: 4.6; mental model resonance: 4.7). Thus, the exceptional performance for Persona C validates the effectiveness of minimalist and predictable behavioral adaptations for focused users, strongly reinforcing the role of precise cognitive-affective alignment in optimizing user experience for uninterrupted concentration and task completion. These results reinforce the role of cognitive-affective alignment in focused experiences and validate scenario-based predictions.

Critically, results across all personas demonstrate that emotional responsiveness can be approximated through behavioral interface design even without live sensing. However, in complex scenarios (e.g., boredom), hybrid systems may be needed to dynamically fine-tune UI responses. This hybrid potential is particularly relevant for sectors like education, health, or banking, where both emotion-sensitivity and technological constraints coexist (*Alipour et al., 2023*; *Matsuda et al., 2018*).

UX fragment analysis also confirms this logic:

- For Persona A, the form flow was redesigned to anticipate time constraints.
- For Persona B, the onboarding interface included exploratory branches, but lacked progressive reduction cues.

- For Persona C, modal prompts were removed entirely and replaced with ambient feedback.

Thus, the detailed fragment-level analysis, combined with the overall expert ratings, strongly supports Hypothesis H2. It demonstrates that while behaviorally adaptive design offers a robust standalone solution for emotional personalization in resource-constrained or ethically sensitive environments, its full potential, particularly in complex emotional states like boredom, is realized through a hybrid deployment model that can dynamically fine-tune UI responses for optimal emotional alignment and user experience across diverse contexts (*Figure 5*).

These results support our second hypothesis (H2), indicating that while behaviorally adaptive design can replace biometrics in constrained environments, full emotional alignment benefits from hybrid deployment.

Discussion

The analysis confirms that a scenario-based behavioral framework can effectively model emotional adaptation logic, providing both a methodological base and future-proof logic for real-time integration. Hypothesis H1 was validated: adaptive behaviors grounded in user personas and affective theory produced perceived emotional alignment without biometrics. H2 was also supported: participants responded most positively when adaptive cues resonated with both mental model and affective state, especially in designs that avoided overstimulation.

The concept of hybrid potential emerges as a critical implication. In practice, low-tech products (e.g., government forms, educational platforms) may deploy behavioral-only models. Meanwhile, in high-stakes systems (e.g., clinical diagnostics, adaptive learning), the same adaptive logic may guide biometric augmentation. The dual role—substitution and supplementation—marks the framework as flexible across UX strata. This duality aligns with early insights by Tao and Tan (*2005*), who emphasized that affective computing frameworks must balance technological capability with ethical interpretability, ensuring that adaptive systems remain context-aware and user-centered.

A key research problem for further discussion lies in precisely quantifying the interplay between behavioral cues and physiological signals in hybrid systems. How can a dynamic weighting mechanism be established to optimally combine these disparate data sources for nuanced emotional adaptation, especially across diverse cultural and contextual settings? Furthermore, questions arise regarding the generalizability of behavioral indicators: can a common set of behavioral patterns reliably predict emotional states across different user groups and interface types, or are highly specific models always required? This reinforces the value of scenario modeling: by anchoring adaptations in persona-based intent, designers can simulate the emotional effect before committing to live sensing infrastructure. Future work should prototype these fragments in hybrid systems with real-time data, testing whether adaptive gains compound when emotional feedback becomes dynamic.

Conclusion

This paper successfully introduces a novel conceptual scenario-based behavioral framework for emotionally adaptive web UX, addressing the limitations of biometric-dependent personalization. The study's methodology meticulously involved developing three distinct synthetic user personas—stressed, bored, and focused—each with unique mental models, and designing corresponding adaptive interface fragments. These adaptations were then rigorously evaluated through a structured heuristic assessment using a comprehensive set of seven metrics, including perceived emotional fit and resonance with mental models.

The interim results consistently validated the framework's core hypotheses. For instance, the "stressed user" persona demonstrated high emotional fit (4.6) and low friction (1.2) with its adapted interface, confirming that behavioral changes can effectively evoke emotional congruence even without real-time sensing. Similarly, the "focused user" persona achieved the highest ratings across all metrics (e.g., 4.7 for mental model resonance), reinforcing the power of cognitive-affective alignment for uninterrupted experiences. While the "bored user" scenario presented challenges (e.g., low engagement 2.9), it critically highlighted the necessity for nuanced, hybrid adaptation logic to avoid overstimulation and disruption of mental models.

In summary, this research confirms that emotional responsiveness in UX can be approximated through behavioral interface design. It establishes a vital "hybrid potential", demonstrating that behavioral adaptation can effectively substitute biometrics in low-tech or ethically constrained environments, and equally, augment them in high-fidelity systems to achieve dynamic fine-tuning. This framework not only fuses emotional design with user mental models but also provides practical tools for UX designers, interface engineers, and HCI researchers. It enables them to tailor UX fragments to emotional cues, identify friction points, and improve early prototyping alignment, thereby strengthening predictive power and enhancing the feasibility of ethically sustainable and scalable adaptive design solutions.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Appendix

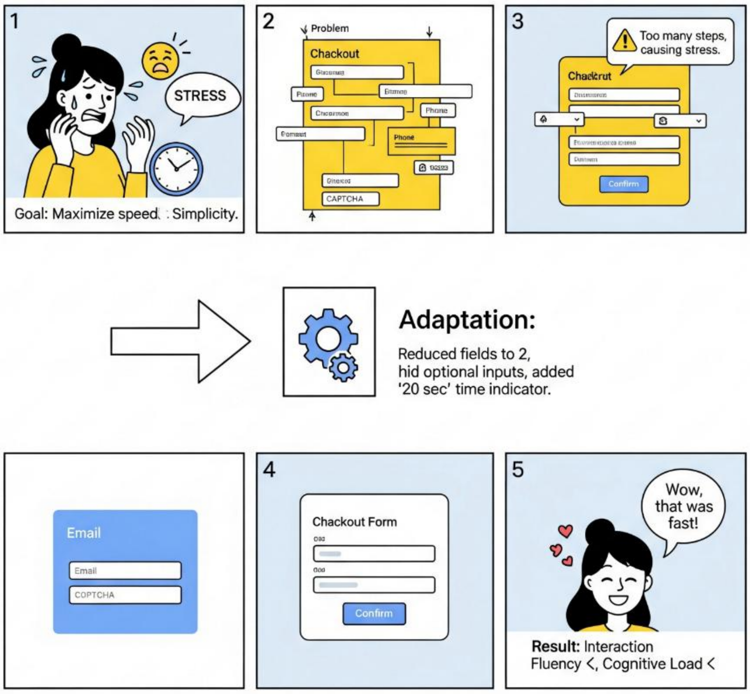

Figure 1. Persona A: The Stressed User

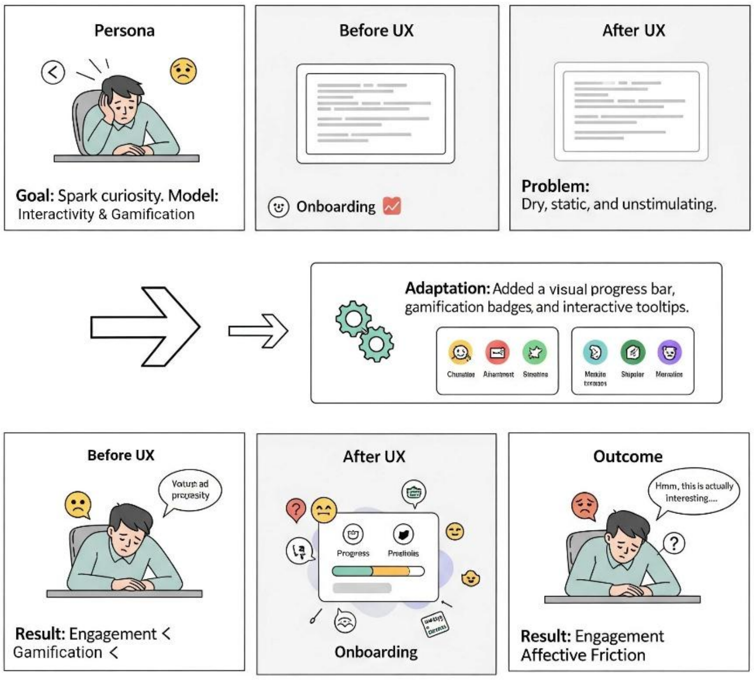

Figure 2. Persona B: The Bored User

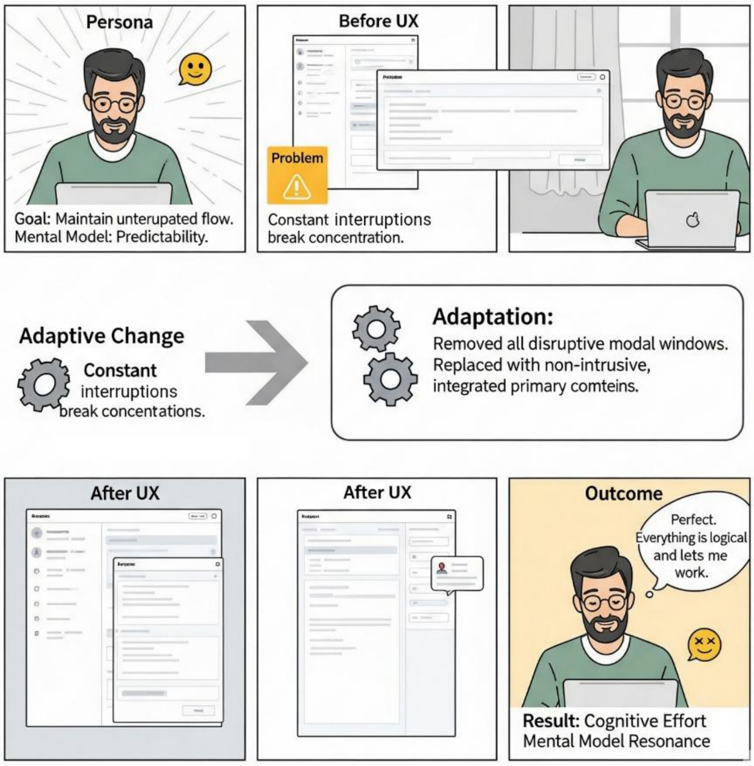

Figure 3. Persona C: The Focused User

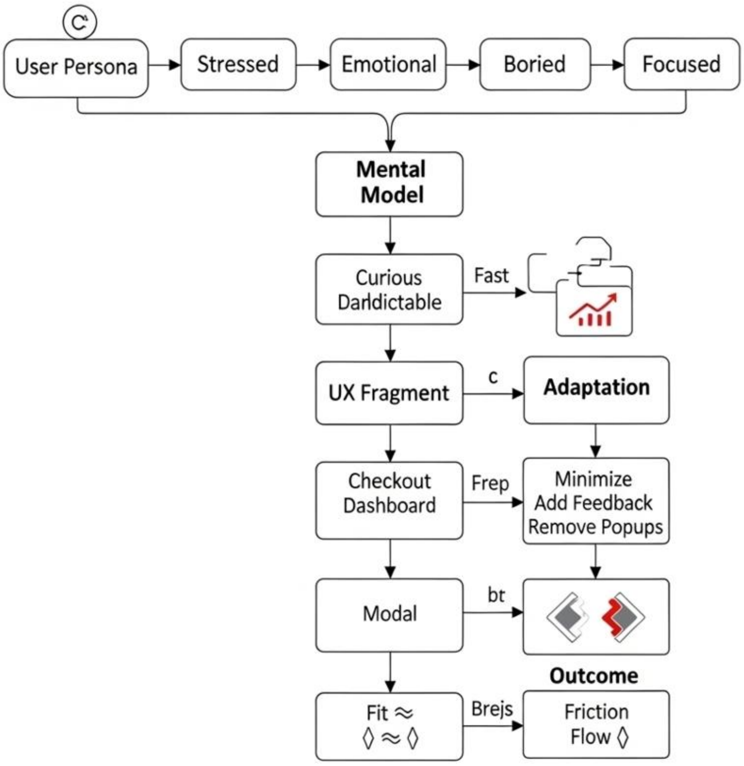

Figure 4. The logic of scenario-behavioral adapation

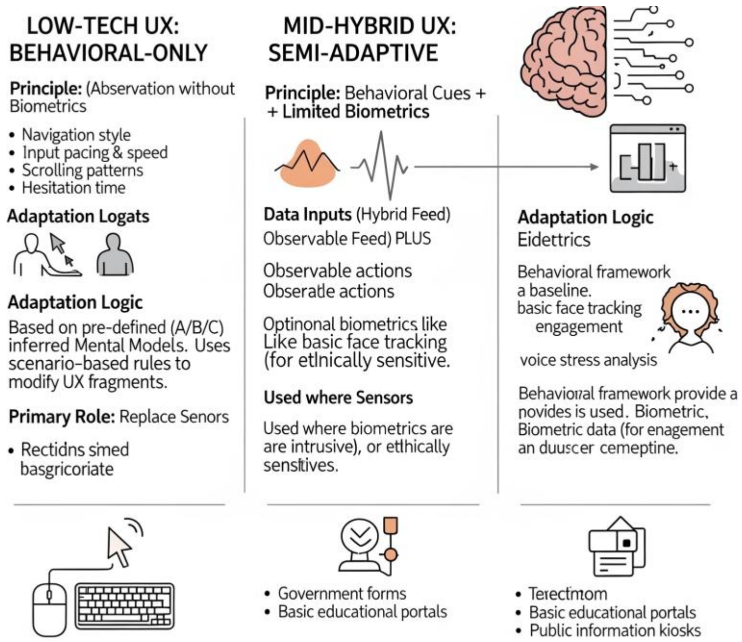

Figure 5. Hybrid Deployment Popential: A Continuum of Emotional Adaptation in UX

Table 1. Expert Ratings for Scenario-Based Adaptive Interfaces (mean scores)

Criteria	Stressed user	Bored user	Focused user
Perceived emotional fit	4.6	3.1	4.4
Cognitive effort	4.5	3.0	4.7
Interaction fluency	4.2	3.4	4.6
Disruption recovery	4.4	3.2	4.5
Engagement stimulation	4.1	2.9	4.4
Affective friction points	1.2	2.7	1.1
Resonance with mental model	4.5	3.0	4.7