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Emotion-Aware Interface Adaptation in Mobile Applications Based on Color Psychology and Multimodal User State Recognition

Ruxin Liang[1*], Feifan FNU[2], Yan Liang[3], Zi Ye[4]

[1] BUCK Design, New York, NY 11232, United States

[2] TiMi Studio Group, New York, NY 10018, United States

[3] Northwestern University – Kellogg School of Management, Chicago, IL 60208, United States

[4] School of Visual Arts (former student), New York, NY 10010, United States

[*]Corresponding Author: rliang1@sva.edu

Abstract

Mobile applications that center on content discovery and lifestyle sharing increasingly involve emotionally influenced user behavior. This study examines how interface visuals can be adjusted in response to users' emotional states, with a focus on visual tone adaptation guided by color psychology. A prototype system was developed that classifies emotional states using facial cues, voice characteristics, and interaction behavior, and then modifies the interface's background colors, content framing and accent elements to reflect the detected affect. The system was evaluated through a controlled within-subject user study, in which 36 participants interacted with three interface versions reflecting distinct emotional tones: Happy, Sad, and Angry. Participants' satisfaction, emotional alignment, and interaction behavior were measured during short usage sessions. Interfaces designed to match positive or low-arousal emotional states were generally associated with higher satisfaction scores and more sustained engagement. In contrast, interfaces that reflected high-arousal negative affect, while consistent with users' moods, often led to shorter sessions and reduced interaction.

The results indicate that emotionally tuned interface visuals can influence both perception and behavior during mobile interaction. Matching interface tone to user mood may improve comfort and alignment, but care is needed when responding to negative affect to avoid reinforcing disengagement. The findings contribute to ongoing work in interface design by showing how affect-sensitive styling, even when applied to basic visual properties, can support more emotionally coherent interaction.

Keywords

Emotion-adaptive interface, Color psychology, Mobile user experience, Multimodal emotion recognition, Human-computer interaction.

1. Introduction

Emotion plays a central role in shaping how users interact with mobile applications, especially on platforms like Xiaohongshu (Little Red Book), where content discovery and shopping behavior are often influenced by mood and emotional context. In such environments, the user interface is not only a visual container but also an affective layer that subtly shapes user perception and decision-making. Despite this, most mobile interfaces remain static, unable to respond to users' moment-to-moment emotional shifts. Studies in human-computer interaction (HCI) have shown that emotions influence attention span, scrolling depth, and engagement

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patterns, suggesting that emotionally aware interfaces could help sustain interest and build stronger user connections [1].

Recent work in emotion recognition has shown that it is possible to identify user affect through lightweight models suitable for mobile use. Recent studies in mobile emotion recognition have demonstrated that lightweight models can classify common affective states using facial expressions with acceptable latency on mobile devices [2]. Subsequent work expanded this capability by incorporating multiple input sources such as facial features, vocal tone, and touch dynamics, thereby enhancing detection performance in everyday usage environments [3]. In parallel, findings in color psychology suggest that specific visual tones influence users' cognitive and behavioral responses. Warm hues such as red and orange have been shown to enhance visual attention and interaction frequency, while cooler tones like blue are associated with prolonged reading and browsing behavior [4]. Other results indicate that when an interface's color style aligns with a user's emotional state, it can improve subjective trust and comfort, particularly in visually dense retail-oriented environments [5].

Efforts to apply emotional cues to interface design have led to systems capable of adjusting layout and color in response to user affective input. Some approaches utilize facial posture and nonverbal signals to modify visual elements dynamically in order to sustain engagement or reduce stress [6]. In applied settings, simple shifts in UI tone or structure based on detected sentiment have been reported to improve satisfaction during negatively charged interactions [7]. Despite this progress, emotion-responsive design remains largely underexplored in social-commerce interfaces, where user moods are fluid and visually expressed. The present work addresses this gap by integrating a mobile-adapted emotion sensing system with an interface styling mechanism grounded in color-emotion associations.

The implementation includes: (1) a multimodal affect recognition pipeline using facial, vocal, and behavioral cues; (2) a color mapping model informed by psychological findings; and (3) a usage scenario and evaluation protocol designed around a Xiaohongshu-style app context. This integrated approach draws on insights from human–computer interaction, visual design, and mobile engagement patterns to explore how interface presentation can better reflect users' emotional context.

2. Related Work

2.1. Emotion Recognition on Mobile Devices

Emotion recognition has become an increasingly important direction for improving user experience in mobile applications. Recent studies have shown that mobile-optimized models can identify affective states such as happiness, sadness, or anger using facial expressions captured through front-facing cameras [8]. Other works have incorporated multiple input signals—such as facial features, vocal tone, and touch interaction patterns—to improve classification accuracy in natural mobile usage scenarios [9]. These advances demonstrate that emotional sensing is now feasible on mobile devices without relying on constrained or lab-based environments.

2.2. Interface Adjustment Based on User Emotion

Research into adaptive interfaces has explored how UI elements can respond to user emotions by modifying layout, color schemes, or visual density. Some systems use facial and posture cues to dynamically adjust interface components in an effort to improve focus or reduce stress during interaction [10]. Others adopt simpler rules, such as shifting color tones or softening layout contrast when signs of frustration are detected in mobile contexts [9]. Although such

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implementations remain limited in scope, they provide early evidence that incorporating affective feedback into UI behavior can support better user comfort and attention.

2.3. The Role of Color in Emotional Experience

Color design is known to influence emotion, attention, and user behavior. Experimental findings have shown that warm color tones—such as red and orange—are often associated with higher arousal and quicker reactions, while cool tones—such as blue and gray—can support longer browsing sessions and a calmer user state. Interfaces that visually align with users' moods have been linked to increased satisfaction and greater willingness to stay engaged. Despite this, most mobile applications continue to rely on fixed visual themes that are not responsive to users' affective state, leaving a gap between emotional context and interface behavior.

3. Method

This study introduces an emotion-adaptive interface system that dynamically alters its visual presentation in response to users' emotional states. The system architecture consists of three main components: emotion recognition, emotion-to-color mapping, and interface rendering, structured as a perception–mapping–feedback pipeline (Figure 1). The system is implemented on a mobile application environment, supporting lightweight inference and responsive visual transformation during real-world interaction.

3.1. Multimodal Emotion Recognition

User emotion is inferred from three primary input modalities: facial expression, vocal tone, and interaction behavior. Facial cues are captured using the front-facing camera and processed by a MobileNet-based convolutional neural network (CNN) trained on labeled subsets of AffectNet. Audio signals collected from in-app voice interactions are analyzed using pitch, energy, and temporal features through a recurrent model designed for short-form speech segments. In parallel, interaction data such as swipe velocity, tap frequency, and pause duration are monitored using predefined behavioral heuristics. These streams are integrated using a rule-based majority decision mechanism with temporal smoothing to classify the user's affective state into one of six categories: Happy, Sad, Angry, Calm, Anxious, or Neutral. A confidence threshold is applied to reduce misclassification and avoid over-triggering visual changes.

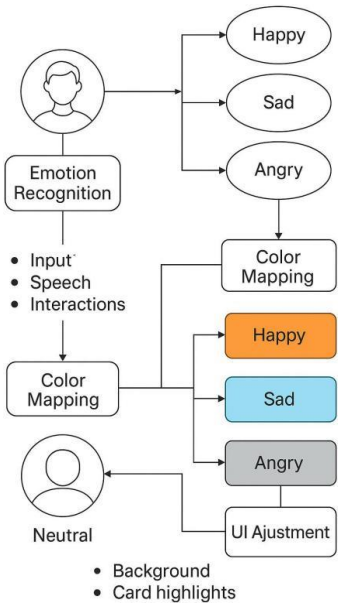

Figure 1. System architecture of the proposed emotion-adaptive interface

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3.2. Emotion–Color Mapping Model

Once an emotion is identified, the system selects a visual theme based on a structured emotion–color mapping grounded in empirical studies on color psychology (e.g., Lüscher, 1969; Valdez & Mehrabian, 1994). Each emotion corresponds to a distinct hue–saturation–brightness (HSB) configuration: for example, Happy maps to warm orange–yellow tones (Hue ≈ 40°, Saturation 90%, Brightness 95%), while Sad aligns with muted blue-gray (Hue ≈ 210°, Saturation 40%). These values are stored in a lookup table with adjustable coefficients based on user preferences or cultural defaults. The mapping model enables straightforward substitution or fine-tuning of visual schemes without altering interface layout or function.

3.3. Adaptive Interface Rendering

The mapped color parameters are applied to the interface through a modular rendering mechanism. Adaptation includes background color changes, adjustment of card elements such as borders and icon hues, and optional mood markers such as smiley icons or emotion state banners (Figure 2). Each adaptation event is animated through smooth transitions (400–600 ms) using Flutter's native theme engine, and updates are triggered only when the emotional state remains stable for a minimum time window. The visual scope of adjustment is constrained to preserve layout continuity while still achieving perceivable emotional tone shifts. Happy-mode interfaces use warm color palettes and high-contrast highlights, Sad-mode interfaces shift toward cooler low-saturation hues, and Angry-mode interfaces employ deep reds with simplified element contrast. These three styles were implemented in a fixed layout prototype (Figure 5) to isolate the effects of visual tone from functional changes.

Figure 2. User interface variants corresponding to three emotional states

4. Experiments and Evaluation

4.1. Objective and Experimental Setup

This study aims to assess whether an emotionally adaptive user interface—one that dynamically adjusts its visual appearance based on real-time emotion recognition and color psychology—can improve user engagement, satisfaction, and emotional congruence in mobile social media applications. A fully functional mobile prototype was developed following the structure outlined in Figure 3, incorporating multimodal emotion sensing (facial expression,

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speech tone, interaction rhythm) and a color-emotion mapping model grounded in empirical psychology literature.

The interface adapted its background color, content framing, and iconography based on the detected user affective state. Three target emotional states were tested: Happy, Sad, and Angry, each corresponding to a distinct UI visual scheme (Figure 3). All other content elements (post content, layout, functionality) remained constant to isolate the effects of color and emotional framing. A within-subject design was employed with 36 participants (18 female, 18 male, ages 18–34), each exposed to all three UI versions in randomized order. Emotional states were induced using multimedia priming: short curated videos and background audio clips (e.g., upbeat music for happiness, ambient rain for sadness, error prompts for frustration). Each condition lasted 4 minutes, during which participants freely explored the app interface and completed a brief questionnaire immediately afterward.

4.2. Evaluation Criteria

The evaluation combined subjective ratings with interaction-level behavioral metrics. Participants rated each interface version using 5-point Likert scales for (1) visual satisfaction, (2) emotional alignment (i.e., perceived congruence between UI style and personal mood), and (3) interface trust, which captured willingness to continue using the app. In parallel, system logs recorded engagement events (e.g., clicks, likes, scrolls) and switch/drop behavior (e.g., abrupt app exits or tab switching). These metrics were chosen to capture both perceived experience and measurable behavioral response under different emotional conditions. All conditions were counterbalanced to control for order effects, and interactions were conducted in a controlled environment to minimize external interference.

4.3. Results and Observations

The adaptive interface yielded statistically significant improvements in both subjective experience and behavioral engagement, especially under Happy and Sad conditions. The Happy UI achieved the highest ratings in satisfaction (mean = 4.56) and emotional alignment (mean = 4.41), while also eliciting more interaction events per session (mean = 16.2). The Sad UI was rated as calm and visually gentle, though with slightly reduced engagement (mean = 14.7). The Angry interface, while emotionally accurate, received lower satisfaction (mean = 3.51) and recorded the highest session exit rate (18.1%), indicating that high-arousal negative states may require additional emotional buffering strategies.

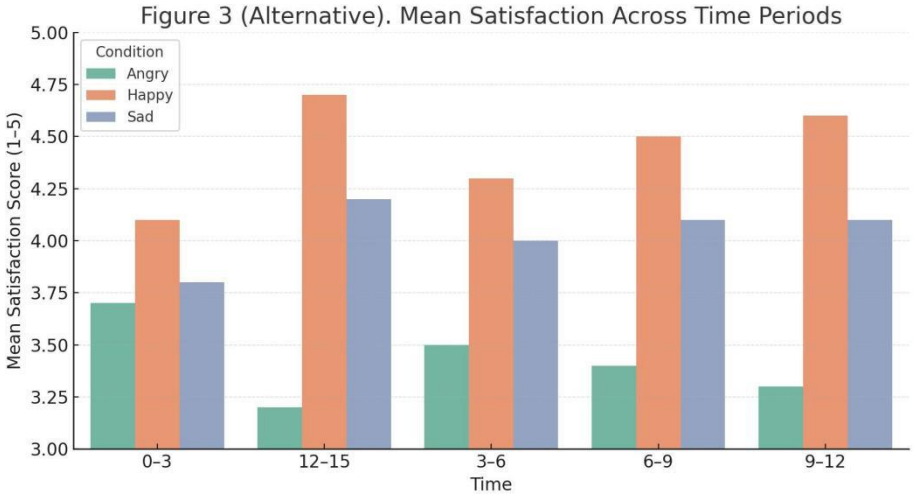

Figure 3. Mean satisfaction scores across time intervals in different UI conditions

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A repeated-measures ANOVA confirmed significant differences across conditions ($p < 0.01$). Qualitative feedback supported the numerical findings: users described the Happy UI as "uplifting" and "encouraging browsing," the Sad UI as "quiet and comforting," and the Angry UI as "visually accurate but emotionally draining." These responses underscore the importance of balancing emotional congruence with psychological relief mechanisms, especially when adapting interfaces in high-arousal negative affect states. Overall, the results suggest that emotion-responsive UI design can significantly enhance affective alignment and interface satisfaction, particularly when coupled with subtle visual modulation strategies rooted in color psychology.

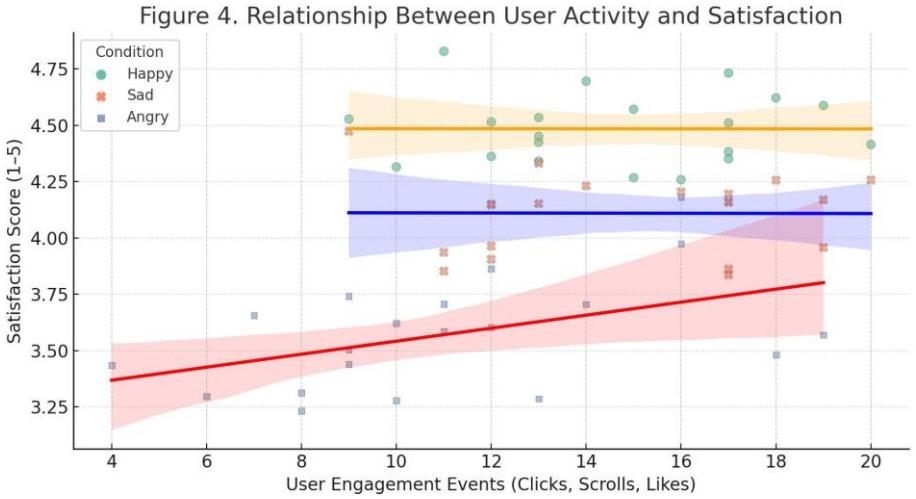

Figure 4. Relationship between user engagement and satisfaction score

5. Conclusion

This study investigated a method for adapting mobile app interfaces based on users' emotional states, combining multimodal emotion recognition with design strategies grounded in color psychology. The system was designed to modify visual elements such as background tones, content framing, and accent colors in response to real-time affective input, with the goal of improving user experience in emotionally sensitive usage scenarios. Through the development of a functional prototype and a structured user evaluation, the approach was shown to enhance both subjective satisfaction and behavioral engagement under certain conditions. Interfaces adapted to positive or low-arousal emotional states (e.g., happiness or calm) were generally associated with higher ratings and longer interaction times. In contrast, while angry-state interfaces reflected users' moods accurately, they often coincided with lower engagement and faster exit behavior. This pattern suggests that the perceived match between interface and mood may not always translate into better usability, especially when users are already experiencing strong negative affect.

Rather than aiming for full emotional mirroring, future iterations may benefit from incorporating more subtle adjustments that acknowledge user emotion while gently steering toward more constructive or comfortable interaction environments. In emotionally dynamic platforms such as lifestyle or social shopping apps, small visual changes grounded in psychological principles may offer a practical and user-respectful way to support engagement without overt intervention. The findings support the broader idea that emotion-sensitive design does not require intrusive personalization or complex adaptation logic to have measurable effects. Even lightweight visual responses, when well-matched to users' current emotional states, can shape perception and interaction patterns in meaningful ways.

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