AI-Assisted Emotional Critique in Visual Communication Design Education: Supporting Affective Intent, Cultural Sensitivity, and Ethical Awareness

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Abstract. The increasing reliance on digital products necessitates that designers address users' cognitive and emotional needs. The AEFC Model integrates Cognitive Load Theory, Emotional Design, and Flow Theory, illustrating the interaction between users' attentional resources, emotional states, and optimal flow experiences. A mixed-methods study tested this model, starting with a pilot study (n = 8) and followed by a larger survey (n = 30). Data collection utilised eye tracking, electroencephalography (EEG), behavioural log files, and semi-structured interviews. Confirmatory factor analyses (CFA) and structural equation models (SEM) examined the relationships between constructs. Findings indicate that depleted attentional capacity leads to negative emotions, obstructing flow states. Furthermore, design factors such as notification frequency and visual hierarchy significantly influence flow, either enhancing or hindering users' sustained attention.

Keywords: Attention-Emotion-Flow Continuum, Affective Design, Cognitive Load, Eye-Tracking, EEG, User Experience.

1 Introduction

The increased amount of time spent using digital platforms has led to a great deal of stress placed upon the minds and hearts of individuals [1]. A condition known as Cognitive Overload is created by the inability of Working Memory (WM) to process the multitude of stimuli presented by an Interface, resulting in a burden that can be emotionally taxing; creating a state of negative arousal and ultimately causing users to abandon tasks. Although Attention, Emotion, and Flow are well studied individually, there has been no model or theoretical construct developed to integrate them into one coherent theory. In this research, we present three primary theories/concepts: 'Attention' which was quantitatively assessed using Eye-Tracking Technology, 'Emotional State' which was qualitatively and quantitatively measured using both EEG and Participant Reports, and 'Flow' which was qualitatively assessed using Surveys. The proposed AEFC Model combines Cognitive Load Theory (CLT), Emotional Design, and Flow

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Theory to describe how they interact. We also provide designers with a conceptual framework that will help designers decrease cognitive and emotional burdens in digital interfaces. We contribute to this area of research by providing definitions of our key constructs, developing an empirically tested methodology, and validating results using Structural Equation Modeling so that developers may create better systems.

2 Background Theories

2.1 Physiological Measures Emotional Design Theories

Eye tracking is able to provide a very accurate and timely method for assessing how users are attending to various aspects of the interface in real time. Common measures that can be taken from this type of assessment are time to first fixate (TTFF), duration of fixation on a particular element, total dwell time, and scan path entropy [2] [3]. For this research, raw data collected using a Tobii Pro Fusion remote eye tracking system at 120 Hz were filtered using a velocity-based fixation filter before the collection of these specific metrics [2]. EEG allows for constant monitoring of neurophysiological correlates associated with both emotional state and cognitive function. The study used a 14-channel Emotiv EPOC X, sampled at 256Hz, using international 10-20 placement as guidelines for positioning. Filtering was performed via a notch filter (for 50 Hz noise), a band-pass filter (to allow for signals in the 0.5-45 Hz range), and independent component analysis (to remove artefactual data). Alpha band frequencies (between .8 and 12 Hz) were indicative of user engagement, and the ratio of theta-band to alpha-band frequencies was indicative of cognitive load. User experience appraisals occur over three stages, visceral, behavioural, and reflective; each is affected in different ways by the aesthetic characteristics and functionality of an interface. Similarly, Cognitive Load Theory divides cognitive load into three categories: Intrinsic, Extranous, and Germane. Using both physiological measures and self-reporting supports the findings of this research through use of complementary verification methods.

2.2 Attention–Emotion–Flow Continuum Concepts

The AEFC conceptualises user experience in terms of moving continuously throughout a three-dimensional space based on the use of attentional resources, an individual's current emotional state (emotional valence multiplied by emotional arousal), and the level of their current flow [Figure 1]. Three directionally-oriented pathways are posited:

- Attention → Emotions: Appropriate and sufficient engagement with attentional resources permits for full evaluation of the interface to which an individual is paying attention and allows for an appropriately emotional response. When an individual has exhausted their available attentional resources, they are likely to have a superficial evaluation of the interface, a negatively-valenced emotional response, and will be likely to abandon their attempts at engaging with the interface.
- Emotions → Attention: Negative high-arousal emotions (such as anxiety or frustration) cause individuals to focus their limited amount of available cognitive resources

toward the immediate task at hand using threat-focused processing. Positive emotions increase an individual's ability to perceive multiple sources of information simultaneously because they allow the individual to expand the scope of their attention. These increased scopes of perception create self-reinforcing cycles that promote exploratory interaction with the system.

- Flow = Attention + Emotion: An individual achieves flow when they have an adequate supply of attentional resources and the overall positive valence of their current emotion is at moderate-to-high levels of arousal, thereby allowing them to become fully absorbed in the activity without experiencing cognitive strain.

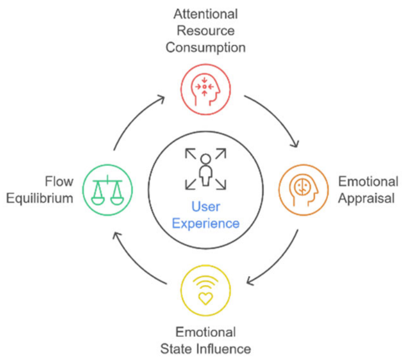

Fig. 1. Attention-Emotion-Flow Continuum Cycle.

3 Research Methods

Mixed methods research design is utilised, which includes a qualitative pilot study (Phase 1, n = 8) that precedes a quantitative study (Phase 2, n = 30) [Figure 2]. The combination of the qualitative thematic findings from Phase 1 and the quantitative results of Phase 2 enables mutual validation among the themes identified in the pilot phase and the quantitative results generated during Phase 2.

3.1 Participants and Sampling

The working professionals who participated in this study are those individuals exposed to various forms of complex digital systems every day. These include healthcare information views, enterprise analytic dashboards, and financial monitoring platforms. Criteria used for participant inclusion included being at least 18 years old, having a minimum of 2 years of occupational digital system use, normal or corrected-to-normal vision, and having no previously diagnosed neurological conditions. There were four female/male subjects in Phase 1 (mean age 31.6 yr); the sample size was selected using purposeful sampling to ensure a variety of areas of domain expertise. For Phase 2 (mean age 33.2 yr; SD = 5.4; N = 30; 16 females/14 males), participants were selected based on their access to professional networks and randomly assigned into one of three categories representing different types of interfaces (n = 10 per category). All participants signed an informed consent document before participating in the study and all studies were conducted in compliance with Institutional Review Board (IRB) guidelines.

3.2 Apparatus and Stimuli

Two versions of each of the three prototypes described above (high-fidelity prototypes created in Figma) were developed for purposes of manipulating cognitive load through varying levels of notification density. Specifically, two notification-density conditions were implemented (notification-density conditions) as follows: low-density notifications, where the number of alerts received was less than or equal to three per minute; high-density notifications, where the number of alerts received was greater than eight per minute. Eye-tracking was conducted using Tobii Pro Fusion (120 Hz; 5 point calibration accuracy ≤ .4 °). EEG recordings were made using Emotiv EPOC X (14 channels; 256 Hz). Behavioural data related to task completion times and errors were captured using event logs. Participants self-assessed their emotional states at the end of each task using the Self-Assessment Manikin (SAM) scale. Flow experience was assessed for participants at the end of each task using the Flow Short Scale (FSS-2) [7].

3.3 Apparatus and Stimuli

Phase 1 (Pilot Study): Subjects completed a think-aloud protocol and semi-structured interview while interacting with all three prototypes under both notification conditions. Audio-video recorders were used to capture all sessions; thematically analysed for identification of commonality among subjects' responses to interaction tasks with each prototype. Phase 2 (Quantitative): Subjects completed a within-subjects counter-balanced design across all three prototypes × two notification conditions (six sessions total, randomised by Latin Square). Each session averaged 20 minutes in length and subject participation time totaled about 90 minutes including all break times. Eye-tracking and EEG were recorded simultaneously throughout all sessions. SAM and FSS-2 scale assessments were completed by participants immediately following each session.

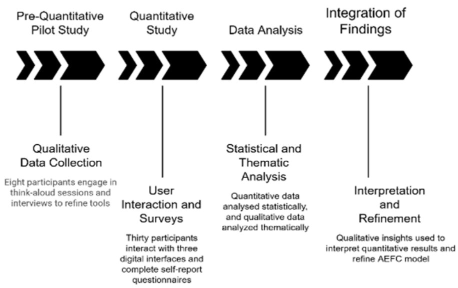

Fig. 2. Mixed-Methods Research Timeline.

3.4 Apparatus and Stimuli

All quantitative data were analysed using SPSS v29 and R v4.3. Pearson's correlation coefficient tests were applied to determine if there existed any bivariate relationship(s) between eye-tracking derived attentional measures (e.g., fixation duration, Time To First Fixation), EEG derived emotional indices, SAM scores, FSS-2 flow scores, and behavioral performance (i.e., task completion time, error rates). Confirmatory Factor Analysis (CFA) was also performed using Maximum Likelihood Estimation to verify the three-factor Attentional Emotional Flow Cognitive (AEFC) construct structure (χ^2 / df = 1.83; RMSEA = 0.048; CFI = 0.96; TLI = 0.95). Structural Equation Modeling (SEM) with bootstraped confidence interval estimates (5000 iterations) were then performed to test the directionally specified causal paths in the AEFC model. Repeated Measures ANOVA was used to examine the effects of notification condition and prototype type on all dependent variables. Explanatory Sequential Triangulation methodology was used to integrate qualitative pilot study themes.

4 Findings

In the qualitative pilot stage, the research revealed that high notification levels disrupt focus before emotional responses can occur. The HealthCare Prototype received low satisfaction scores (Mean 2.1 / 9), while the Enterprise Analytics Prototype created brief flow experiences hindered by notification disruptions. The Financial Dashboard Prototype elicited high emotional arousal but limited prolonged flow due to users feeling out of control. Key disruptors included ‘Notification Overload,’ ‘Confusion in Visual Hierarchies,’ and ‘Linear Task Progression.’ The quantitative phase, with 90 sessions, showed significant variance in Mean Attention (4.63) and Mean Flow Scores (4.21), indicating that fewer notifications led to higher scores. Structural Equation Modeling indicated that attention significantly affected emotion (beta = .52), which in turn affected flow (beta = .44), supporting an indirect relationship between attention and flow through emotion (beta_indirect = .23). Additionally, alpha EEG power showed an inverse relationship with SAM Negative Valence (r = -.41), confirming the physiological validity of the Emotional Burden Measure.

5 Discussion

The AEFC model is a synthesis of data from three fields: Human Computer Interaction (HCI), Cognitive Psychology, and Affective Computing [2] [3] [4] [5] [6] . The SEM confirmed pathways show how emotion completely mediates the relationships between Attentional Depletion and Flow Disruption for users of Complex Digital Systems. The inefficient distribution of attention (High Extraneous Load) for users of enterprise dashboard can be addressed with progressive disclosure and contextual notification management. For healthcare professionals working in high-stake environments, emotionally-aware designs will help protect them from excessive negative emotional responses.

In addition, financial applications need to give users a sense of control over their interactions so they do not experience high arousal levels that disrupt flow. Social Media Interfaces exploit pseudo-flow through Variable Reward Notification Schedules that are identified as an Ethical Design Concern by the AEFC Model. Limitations include; the relatively small sample size used in Phase 2 of this study (n = 30); the fact that the prototypes were simulated rather than actual production systems; and the fact that all participants were from one cultural background.

6 Conclusion

This study supports the AEFC model, demonstrating that managing cognitive load through notification frequency and visual hierarchy effectively maintains attentional engagement and influences emotional states in complex digital interfaces. Confirmatory Factor Analysis and Structural Equation Modeling validated the model's structure and causal relationships. Recommendations include limiting alerts to no more than 3 per minute, using progressive disclosure to reduce cognitive load, and providing positive emotional feedback during tasks. Future research should replicate these findings in real-world settings, investigate cultural or individual moderators of the attention-emotion-flow relationship, and examine the impact of long-term use of adaptive interfaces on these causal relationships.

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