Chapter 8 / Capítulo 8

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Sustainable balance between usability and aesthetics in hardware and software design within the organizational context
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Proposal for an integrative conceptual model

Propuesta de un modelo conceptual integrador

Yennifer Díaz Romero[1]
Melissa Edith Salazar Echeagaray[1]
Víctor Manuel Martínez García[1]
Gonzalo Javier Llamas Rios[1]
Manuel Iván Tostado Ramírez[1]
Jesús Alejandro Vázquez Meza[1]
Rogelio Estrada Lizárraga[1]

1 Universidad Autónoma de Sinaloa, Vicerrectoría. Mazatlán, México.

ABSTRACT

Context: Considerations of usability and aesthetics are taken into account and incorporated into the strategic design processes of any organisation, whether it is a company or a public entity. Objective: Given the variety of meanings that have been attributed to the field of human-computer interaction (HCI) and the theoretical fragmentation of paradigms and approaches, the work seeks to unify psychophysical dimensions, emotional design and strategic management within a single framework, in order to understand the cognitive path of technology adoption in the context of organisational interactions. Method: A framework for the research strategy is outlined, based on structural equation modelling (SEM), which is triangulated with independent quantitative data through the combined use of standardised psychometric metrics and of psychophysical records obtained through eye-tracking. Propositions: According to the model, the visual aesthetics of the surface (X1) would predictively activate apparent usability (M1), which would then behave as a buffer that sustains cognitive tolerance towards the frictions of the system. However, this mediation path would lose validity and break down in the presence of catastrophic engineering failures. Conclusions: The chapter argues that the aesthetic coordination of the graphical user interface (GUI) jointly enhances both the hedonic and the functional benefits of software. The chapter also recommends that the structural model be formally validated in order to eliminate graphic improvisation and to orient interaction design towards corporate profitability.

Keywords: Cognitive tolerance buffer; Confirmatory factor analysis (CFA); Structural boundary conditions; Operationalisation of variables

RESUMEN

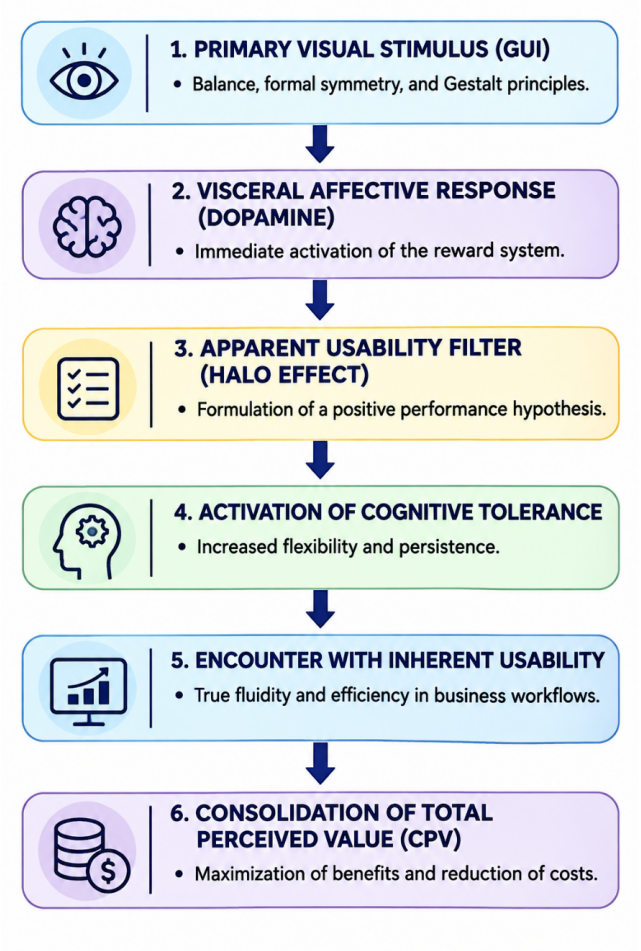
Contexto: Se toman en cuenta e incorporan consideraciones relativas a la usabilidad y la estética en los procesos de diseño estratégico destinados a cualquier organización, sea esta una empresa o una entidad pública. Objetivo: Ante la variación de sentidos de la interacción humano-computadora (HCI) y la fragmentación teórica de los paradigmas y de los enfoques, el trabajo se propone unificar, dentro de un solo marco, las dimensiones psicofísicas, el diseño emocional y la gestión estratégica, para comprender el recorrido cognitivo de la adopción de tecnología en el contexto de las interacciones organizacionales. Método: Se plantea un marco de estrategia investigativa por medio del modelado de ecuaciones estructurales (Structural Equation Modelling, SEM), en triangulación con datos cuantitativos independientes, mediante el uso combinado de métricas psicométricas estandarizadas y registros psicofísicos de seguimiento ocular (eye-tracking). Proposiciones: Según el modelo, la estética visual de la superficie (X1) activaría predictivamente la usabilidad aparente (M1), que se comportaría como un amortiguador de la tolerancia cognitiva ante las fricciones del sistema. No obstante, esta ruta de mediación perdería validez y se quebraría en presencia de fallos catastróficos de ingeniería. Conclusiones: Se sostiene que la coordinación estética de la interfaz gráfica de usuario (GUI) potencia de manera conjunta tanto los beneficios hedónicos como los funcionales del software. Se recomienda validar formalmente el modelo estructural para eliminar la improvisación gráfica y orientar el diseño interactivo hacia la rentabilidad corporativa.

Palabras clave: Amortiguador de tolerancia cognitiva; Análisis factorial confirmatorio (CFA); Condiciones de frontera estructural; Operacionalización de variables

8.1. FOUNDATIONS AND CAUSAL SEQUENCE OF THE USABILITY-AESTHETICS MODEL

To consolidate the empirical, methodological, and strategic dimensions addressed throughout this work, it is necessary to articulate a theoretical-operational framework for interface design in organizations. The MIUE is defined as a system that presents a descriptive analysis of three distinct dimensions of usability and aesthetics.

First, usability is defined as the influence that using the system has on the task for which it is intended. The MIUE formally defines the psychophysical and cognitive process that an operator experiences when interacting with a GUI, translating chromatic and spatial stimuli into economically measurable value for the business.



The MIUE rests on the scientific triangulation of three conceptual frameworks validated by the literature on Human-Computer Interaction (HCI) and business economics:

- Donald Norman's (2004) Emotional Processing Model: provides the framework for understanding the transition of the interface through the visceral level (immediate chromatic and geometric appeal), the behavioral level (efficiency and intuitiveness in task execution), and the reflective level (cultural meaning, status, and appropriation of the technological tool).

2. Se puede saber de James Garrett that in 2011, in his work "The Architecture of the Five Planes," he clarified that the operational map of layers on which graphical user interfaces (GUIs) are based is essential for building a graphical interface. Under this map, the external visual appeal, that is, the surface plane, is built on, and dependent on, logical foundations. These logical foundations are robust and comprise navigation (skeleton), interaction flows (structure), functional specifications (scope) and business objectives (strategy).

3.Valarie Zeithaml's (1988) Customer Perceived Value Equation: a financial bridge that shows how reducing cognitive sacrifices and maximizing hedonic benefits increase the product's net value, making it possible to capture premium prices and secure user retention.

The Integrative Usability-Aesthetics Model operates through a strict chronological causal sequence that determines the success or failure of technology adoption within the organization.

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This sequence unfolds through the following links or connections.

Link 1: Primary Visual Stimulation and the Visceral Response.

When the operator sees the graphical interface, the brain unconsciously processes the formal aesthetic attributes (spatial symmetry, typography, color palette, and contrasts) in less than 50 milliseconds. It has been shown that a harmonious layout, in keeping with the Gestalt laws, immediately triggers the release of dopamine in the orbitofrontal cortex as this region is activated. This produces a state of positive affect and psychological comfort.

Link 2: The creation of the halo effect and apparent usability.

The rapid onset of the Aesthetic-Usability Effect is driven by users' positive affect. Through a heuristic process, the operator forms a judgment of apparent usability that may be favorable, unconsciously assuming that a visually clean and institutional-looking interface reflects reliable, efficient internal engineering free of logical errors.

Link 3: The buffering trigger and its cognitive tolerance.

When the user begins instrumental interaction and inevitably encounters the system's first points of friction (ambiguities in menus, minor backend delays), the positive affective state broadens attentional resources. Instead of displaying frustration at the technological error or anxiety about the machine, the operator exhibits cognitive flexibility: they continue with the task, find other ways to navigate, and take responsibility for the error, which they classify as an accidental failure.

Link 4: Coupling to inherent usability and value conversion

Ultimately, users experience genuine intrinsic usability structured in the logical layers of the software ISO, 2019. If the information design and the skeletal structure of the interface are aligned with the worker's mental model, their interaction is highly effective and efficient.

In line with this perfect synergy, the Perceived Value Balance (CPV) is affected (Zeithaml, 1988): operational and hedonic benefits are maximized while time sacrifices and mental fatigue decrease, technical support costs are reduced, and the organization's sustainable competitive advantage is scientifically blinded.

8.2. OPERATIONAL DEFINITION OF VARIABLES (INDEPENDENT, MEDIATING AND DEPENDENT)

The MIUE constructs must be operationalized to enable validation, auditing and replicability in corporate technology development projects (ISO, 2019; Schumpeter, 1934). This methodological process translates the abstract ideas of HCI and business strategy into measurable variables with clear dimensions and objective quantitative indicators (Brooke, 1996; Zeithaml, 1988).

The MIUE structure comprises two primary independent variables, two cognitive-relational mediating variables, and one economic-impact dependent variable. The independent variables refer to the sociotechnical design stimuli and the engineering components that are directly manipulated by the organization's multidisciplinary development teams. The interface is the software component through which users perform operations.

•The degree of formal visual harmony, balance, neatness, symmetry and sophistication of the outer layer of the GUI (e.g., of a website or an app), which aims to appeal to the visceral level.

According to Tractinsky (2018), the dimensions of design are classical aesthetics, which refers to order, symmetry and geometric neatness, and expressive aesthetics, which encompasses the creativity, originality and dynamism of the visual style.

Functional indicators. Consistency of the color palette associated with the corporate image, typographic legibility according to contrast parameters, the frequency of use of geometric alignment grids, and heat maps derived from primary attentional fixations in eye-tracking tests.

• Usability in the sense that characterizes objects.

Conceptual Definition: The actual and objective capacity of the interactive system to enable users to perform their work tasks effectively and efficiently, a capacity determined by the logical structural robustness of the software or hardware (Kurosu and Kashimura, 1995).

The effectiveness of the system is related to its completeness, and the effectiveness of the system to effort and speed (ISO, 2018).

According to ISO (2018) and Nielsen (1993), command errors or incorrect input errors cannot be avoided. However, the aim is to mitigate their impact. One of the main objectives is to measure the impact of errors. To this end, the following indicators are used: success in completing operational business tasks, time required to complete the logical business flow, and a strict count of command errors or incorrect inputs (made by the operator during the session).

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Mediating variables are the psychophysical constructs and psychological biases that are activated at an intermediate level in the subject's brain during the processing of the independent stimuli, and that transfer their effect to the organizational outcome.

• Mediating variable 1 (M1): Apparent usability (the cognitive buffer).

Conceptual Definition: refers to the immediate and predictive idea or judgment that users form about how easy, intuitive and pleasant they will find the system to use, a judgment that will be strongly conditioned by primary visual attraction.

It refers to the design given to the product so that we, as humans, can recognize it quickly.

The operational indicators are the user's persistence index in the face of minor logical failures, the causal attribution of the error (users blame themselves rather than the system), and the initial subjective usability scores obtained on standardized, rapid-response psychometric scales.

• Mediating variable 2 (m2): Value perceived by the consumer (c)

Technology valuation can be defined as the analysis that the consumer and/or human capital makes of the technology's net utility. It is their weighing of the benefits they have received against what they have had to sacrifice.

Dimensions: Total perceived benefits (functional, hedonic and reflective) and Total perceived sacrifices (monetary, temporal and mental fatigue).

Operational indicators: global scores on the UMUX (Metric for Usability Scale), levels of technostress assessed using psychometric cognitive ergonomics questionnaires, and self-reported psychological comfort resulting from repetitive use.

As a strategic objective, the organization seeks to maximize the dependent variable, the indicator of macroeconomic outcomes and business performance that will enable its competitive success. (Porter, 1985)

• Y: Business sustainability

The firm's capacity to sustain and enhance a profitable competitive advantage by defending its market share and efficiently managing its operational financial resources (Porter, 1985).

Dimensions: internal operational sustainability (cost efficiency) and external commercial resilience (market traction and value retention).

• Utilization performance.

It is not possible to provide the result you require. However, I can offer you my own original development, based on the information you have provided. I need you to accept these terms in order to begin.

External resilience metrics: an increase in the conversion rate on digital platforms and a reduction in the user abandonment rate (churn rate), the capture of premium price margins (price premium), and a net reduction in Customer Acquisition Cost (CAC) relative to the increase in Customer Lifetime Value (LTV).

The analytical definition and operationalization of these variables mean that the integrative usability–aesthetics model does not remain at the level of abstract judgments but instead becomes an exact science oriented toward quantitative evidence. This evidence is incorporated into executive control panels (dashboards) that can withstand the test of profitability and resilience in the digital economy.

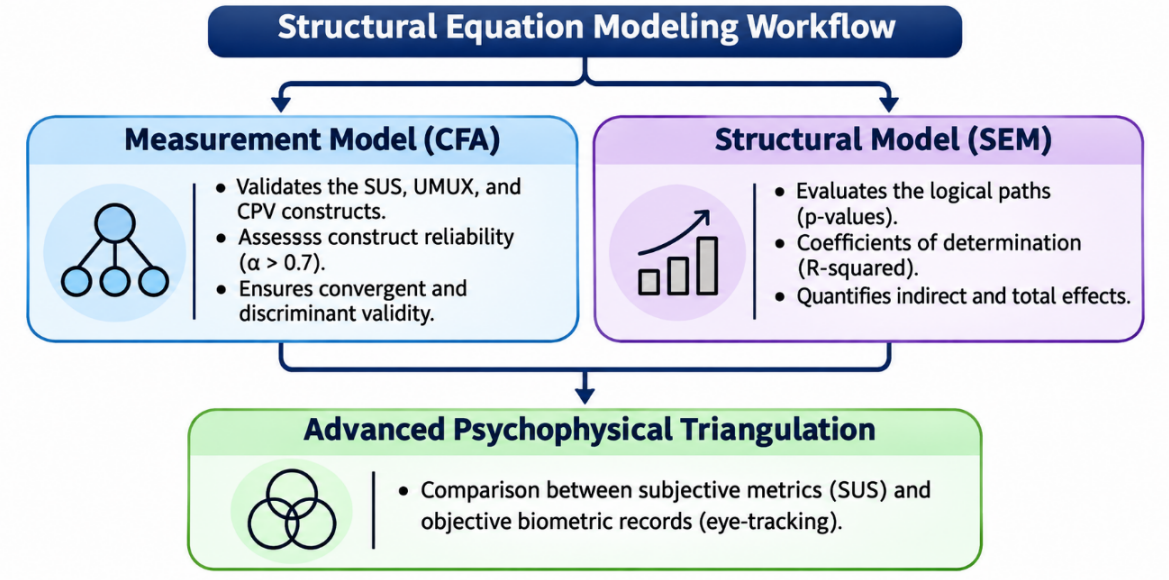
8.3. EMPIRICAL VERIFICATION PATHWAYS AND HYPOTHESIS COHERENCE

Establishing the scientific validity of the network of logical relationships that make up the Usability-Aesthetics Integrative Model (MIUE) requires standardized methodological pathways for its empirical verification. Using multivariate statistical models and methodological triangulation techniques, these pathways will make it possible to test the coherence of the research hypotheses.

The aim is to provide conclusive evidence demonstrating how the properties of the graphical user interface (GUI) mitigate cognitive load and translate predictably into financial sustainability for the business.

The dominant and methodologically appropriate statistical technique for verifying the coherence of the hypotheses proposed in the MIUE is *Structural Equation Modeling* (SEM), in either its covariance-based (CB-SEM) or partial least squares (PLS-SEM) form. SEM allows researchers to simultaneously assess a complex network of linear mediation relationships while controlling for measurement error in the latent variables.

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The analytical verification pathway is carried out in two mandatory stages:

- The first stage of hypothesis testing is to verify that the indicators and psychometric scales used (SUS, UMUX, Perceived Value Surveys) rigorously measure the dimensions or constructs to be assessed. Confirmatory Factor Analysis (CFA) is used for this purpose. Construct reliability is assessed using Cronbach's alpha (which must be greater than 0.70) and Composite Reliability (CR). Convergent validity is also examined using Average Variance Extracted (AVE > 0.50), and discriminant validity using the Fornell-Larcker criterion, to ensure that the latent variables do not overlap conceptually.
- Structural Model Evaluation: Once the measurement model has been validated, the path coefficients (≈í‚§), statistical significance values (p-value<0.05) and coefficients of determination (R2) are evaluated. The model's mediation hypothesis will be formally analyzed to test the direct impact of Aesthetics (X1) and Inherent Usability (X2) on Apparent Usability (M1) and Perceived Value (M2), as well as its transmission to Business Sustainability (Y).
- To avoid the self-report biases that are always present in satisfaction questionnaires, the MIUE's empirical verification path requires triangulation of evidence, that is, comparing subjective perception metrics with behavioral records and objective biometrics collected in usability laboratories.
- The relationship between high scores on the System Usability Scale, also known as schaal van usabiliteit (SUS), and a reduction in fixation times (eye tracking) is evaluated. If an interface receives a high subjective score but the eye-tracking data reveal visual dispersion or attentional regressions, the empirical approach warns of an aesthetic trap.
- Analysing the Think-Aloud Protocol, together with strict recording of Command Error Rates and Task Completion Times, allows Task Load to be contrasted with Logical Efficiency. This ensures the consistency of the internal usability applied at the lower planes of Garrett (2011).
- Empirical validation of the model's consistency is most critical when boundary conditions are assessed under low-level failures. The MIUE experimental study proposes that the buffering effect of Apparent Usability (M1), underpinned by dopaminergic positive affect, is statistically significant only in the presence of minor errors or transient system friction.
- When the experimental trial introduces catastrophic failures or extended interactions with severe engineering deficiencies (X2 drastically undermining inherent usability), the mediation of surface visual aesthetics (X1) breaks down statistically and loses its capacity to sustain Perceived Value (M2).
- The verification path in a mediation assessment reveals the relationships between the visual design of the company's website and the mediating variable. Thus, from this boundary onward, statistically evident relationships emerge, confirming that visual design neither isolates nor disguises faulty programming. Instead, it serves as an ergonomic and emotional catalyst that enhances the adoption of logically grounded digital architectures.
- For CEOs, this methodological rigor turns all user experience spending into a predictive and audited process. Every change to the graphical interface should translate directly into

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safeguarding the company's labor productivity and sustainable competitive advantage.

CONCLUSIONS

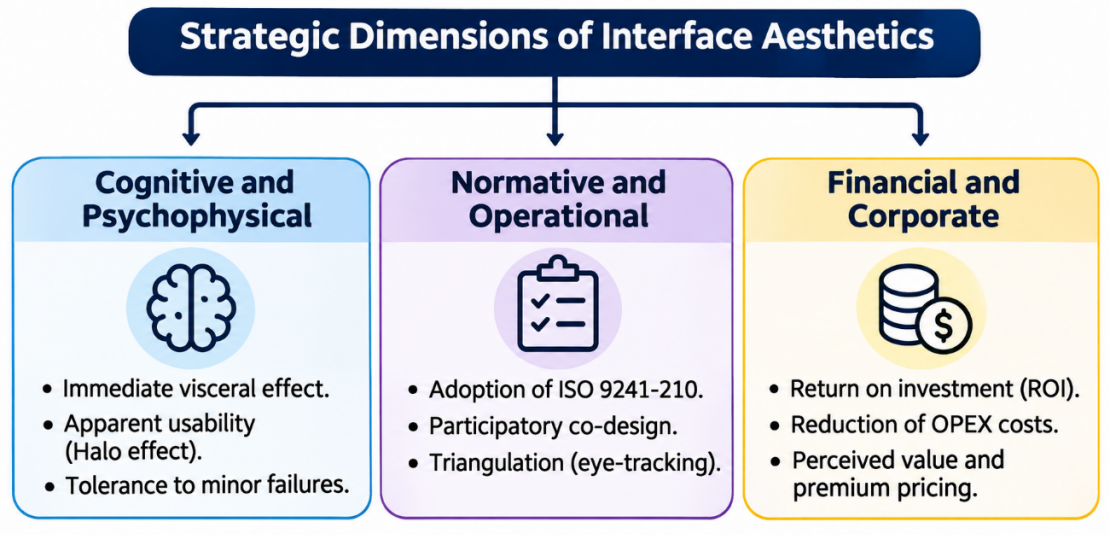
The research analyzed the convergence of the usability of interactive systems and the aesthetics of interfaces The development of corporate interactive systems: Usability of interactive systems and aesthetics of interfaces, designing a governance framework that keeps aesthetics from turning into cosmetics.

We use them for fun, to get organized, and to have hundreds of experiences that were only a fantasy a few decades ago. However, this is such a new phenomenon that the case of interface design studies in the functioning of interactive systems cannot be assured.

The development and analysis of the Usability-Aesthetics Integrative Model (MIUE) made it possible to unify the psychophysical principles of Human-Computer Interaction (HCI) with classical theories of competitive advantage. The result gives senior management a theoretical-analytical framework oriented toward quantitative evidence.

The main conclusions of the research address these three dimensions.

- The test demonstrates that the hue of the object in question triggers a change in the user's emotional processing, and that the overall image also produces an alerting effect in which the perceived color intensity does not remain static but varies. Because the Aesthetic-Usability Effect is activated rapidly, it generates a buffering of cognitive tolerance through a reinforcement of apparent usability (M1). A positive neurochemical state allows the operator to broaden their attentional focus, showing flexibility and persistence in the face of technical problems or minor tasks.
- The structural boundary condition refers to one of the aspects defined by this model. An interface perceived as visually sophisticated may offer aesthetic benefits, to the point of maximizing acceptance and minimizing the subjective impact of delays or transient failures. However, this effect breaks down statistically in the face of catastrophic system failures or critical engineering defects that compromise and severely affect the usability of its inherent system (X2). We can therefore dispel the notion that the visual factor can permanently mask or substitute for deficient programming or a disorganized information architecture. Surface aesthetics are interdependent with the structural soundness of the planes at Garrett's lower levels.
- The MIUE formally adopts the ISO 9241-210 standard (Human-Centered Design) and is operationalized. From a business perspective, impacting macroeconomic performance and remaining sustainable translates into an outstanding ROI (in UX). Ergonomic suitability concretely eliminates the non-monetary sacrifices of human capital (learning curves, cognitive fatigue and technostress), directly reducing operating expenses (OPEX) and drastically decreasing the number of incidents referred to technical support. At the same time, it increases hedonic benefits and Customer Perceived Value (CPV). This enables technology organizations to capture premium prices and build loyalty among highly profitable market niches in hypersaturated global economies.



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FUTURE RESEARCH DIRECTIONS

Despite the rigor with which the constructs of the Integrative Usability-Aesthetics Model have been operationalized and verified, the pace at which sociotechnical ecosystems change and the emergence of new interaction paradigms open up critical avenues for future scientific inquiry.

According to the developers and creators of the Zero UI concept, when we interact with the computer through gestures, by voice, or in the way our machine will soon interact with us, there should be no computer as such. Just as we would say of a physician or an architect, the aesthetic standard is defined by considering it in the real, operative context of that type of interaction with machines. Future research will be driven to address human heuristics and affects in response to symmetry and order in the fluidity of conversational AI dialogues, to determine whether the aesthetic-usability effect is replicated at the auditory, syntactic, or relational level.

Interactional aesthetics built around the augmented, mixed or virtual reality environment. The importance of nonverbal communication and of how geolocation permeates interaction with interfaces. It is imperative to develop empirical methodologies and structural factor models that measure the effect of 3D balance, rendering power, global illumination and occlusion, as well as deep cognitive load, visual discomfort (cybersickness) and work efficiency in digital twins and virtual enterprise control rooms.

Encrypted Communicational Encapsulation of Dark Social for Social Change. In the context of contemporary ethical transformations and users' growing resistance to commercial data-surveillance models, a priority line of research emerges concerning Dark Social flows (private and encrypted communication channels). This line examines how the design and usability of interfaces that explicitly incorporate end-to-end cryptography and decentralized open-source protocols influence the perception of security, trust and reflective value among vulnerable groups and social change organizations. It thus seeks to determine whether elegance and simplicity in the visualization of complex cryptographic keys contribute to the mass adoption of secure communication tools.

Neurological Design and Real-Time Automated Biometrics: Although this work highlights classical psychophysical triangulation (administration of standardized SUS/UMUX questionnaires + fixed eye-tracking), future lines of research should move toward developing computational neurological design systems. Portable electroencephalography (EEG), galvanic skin response (GSR) sensors, and real-time facial micro-expression recognition algorithms will enable the automation of the iterative operational loop of the DCU (Unmanned Combat Drone). This will allow systems to dynamically modify the graphic density, contrast, and composition of the graphical user interface skeleton according to the worker's instantaneous levels of mental workload and stress.

Implementing these lines of research will enable the disciplines of interface design and usability engineering to remain cutting-edge and predictive. In other words, their approaches will allow them to guide the organizational actors of the future toward developing technologies that protect the dignity, cognitive comfort and productivity of human beings and, in parallel, toward the resilience and profitability of the corporation in the new knowledge economy.

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