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When technology fails: A neurophenomenological model of human intervention in phygital customer journeys

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Article Info	Abstract
Original article Main Object: Business & Economics, Phygital Customer Journeys Received: 03 April 2026 Revised: 01 May 2026 Accepted: 01 May 2026 Published online: 21 July 2026 **Keywords:** electroencephalography (EEG), human intervention, neurophenomenology, phygital customer journeys, service recovery, technology failure.	**Background:** The modern retail landscape is undergoing a structural transformation, one defined not merely by the adoption of new technologies but by the fundamental reconstitution of the service encounter itself. Across sectors ranging from consumer electronics to luxury fashion, retailers are deploying interactive kiosks, augmented reality displays, AI-driven recommendation engines, and sensor-embedded product zones in a deliberate effort to dissolve the boundary between the physical store and the digital platform. **Aims:** This study investigates the experiential and neurophysiological dynamics of technology-based service failures in physical retail environments to develop a theoretical model for effective human-led service recovery. As retailers increasingly automate the customer journey, technology failures represent a critical threat to customer experience, creating a paradoxical need for skilled, human intervention. **Methodology:** This research employs a neurophenomenological approach, integrating first-person data from Interpretative Phenomenological Analysis (IPA) with third-person, objective data from electroencephalography (EEG). A video-cued recall protocol was designed to capture rich, in-the-moment experiential accounts from eight participants in a flagship phygital electronics store, while ensuring high-fidelity, artifact-free neural data. Data saturation was confirmed after the eighth participant, justifying the sample size within IPA norms. **Findings:** The analysis revealed that technology failures induce a distinct "neural signature of frustration", characterized by negative emotional valence (low Frontal Alpha Asymmetry), high cognitive load, and profound disengagement. Conversely, effective human intervention acts as a regulatory mechanism, resolving technical issues and transforming this negative state into a more positive and engaged emotional state. This "Human Anchor" role, dependent on employee competence and situational awareness, is particularly critical in low-trust market contexts where the physical store functions as a validation point for the online brand. **Conclusion:** Theoretically, this study extends service recovery theory into the phygital domain by proposing a model of human intervention as a cognitive-emotional regulation mechanism. Methodologically, it validates a neurophenomenological protocol for consumer research, bridging the gap between subjective lived experience and objective neurophysiology.

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1. Introduction

The modern retail landscape is undergoing a structural transformation, one defined not merely by the adoption of new technologies but by the fundamental reconstitution of the service encounter itself. Across sectors ranging from consumer electronics to luxury fashion, retailers are deploying interactive kiosks, augmented reality displays, AI-driven recommendation engines, and sensor-embedded product zones in a deliberate effort to dissolve the boundary between the physical store and the digital platform. This convergence has produced what scholars increasingly term the "phygital" experience: an integrated mode of service delivery in which digital touchpoints and physical spaces are not simply collocated but functionally and experientially fused into a unified customer journey (Batat, 2022; Flavián et al., 2019). The phygital paradigm has migrated rapidly from the experimental periphery to the strategic core of retail management, reflecting a broader recognition that value creation in contemporary markets depends on the intelligent orchestration of human presence and technological capability across seamless, multi-touchpoint environments (Grewal et al., 2020; Mele et al., 2021).

Yet the intensification of technological mediation within service environments carries with it a paradox that the marketing literature has been slow to address with the depth it deserves. The very technologies introduced to streamline and enrich the customer journey are themselves susceptible to failure— and when they fail, the consequences extend well beyond procedural inconvenience. Technology-based service failures, understood as breakdowns in automated or digitally mediated service systems that fall below customer expectations, generate significant customer dissatisfaction, cognitive frustration, and behavioral withdrawal from the service encounter (Ozuem et al., 2021). In phygital contexts specifically, where consumers actively anticipate high-convenience, high-control interactions— the foundational promises of self-service and smart retail infrastructure— unexpected failures are experienced as particularly acute violations of the implicit service contract. A customer who encounters a frozen kiosk or an unresponsive augmented reality interface does not merely lose time; they lose agency, clarity, and emotional equilibrium in the very space the brand has constructed as a site of experiential promise.

The service recovery literature has long established that organizational responses to service breakdowns shape customer evaluations more powerfully than the failures themselves. Research grounded in justice theory has demonstrated that customers assess recovery efforts along three interrelated dimensions: distributive justice (the fairness of outcomes), procedural justice (the fairness of processes), and interactional justice (the quality of interpersonal treatment during resolution) (Russo et al., 2022). It is this third

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dimension that proves most consequential in the phygital context: automated systems are inherently incapable of delivering the empathy, respect, and dignity that constitute interactional justice, and it is therefore the frontline employee— intervening in the aftermath of technological failure— who must perform this regulatory function.

However, service recovery theory has developed primarily in traditional human-to-human service contexts and has not been systematically extended to phygital environments, where failures are depersonalized, sudden, and experienced without immediate human mediation. This gap represents a significant theoretical lacuna at a moment when the phygital model is becoming the dominant template for retail experience design globally.

Addressing this gap demands not only theoretical innovation, but methodological innovation of an equivalent order. The experience of technology failure in a phygital store is not a behavioral event adequately captured by attitudinal surveys or post-hoc interviews alone. It is a lived, embodied, and neurophysiologically grounded moment of disruption, constituted simultaneously at the levels of conscious perception, cognitive load, emotional valence, and motivational orientation. Understanding this experience in its full complexity requires tools that can bridge the subjective, first-person dimension of the encounter— the felt quality of frustration, disengagement, or relief— with objective, third-person measures of the neural processes that underlie these states. It is precisely this explanatory gap that Francisco Varela's neurophenomenological research program was designed to close. Varela's foundational proposition held that first-person phenomenological accounts and third-person neurophysiological data should be brought into a relationship of "reciprocal constraints" or "mutual illumination", with each data stream iteratively informing and refining the interpretation of the other (as reviewed in Sandved-Smith et al., 2025). Despite the proven theoretical power of this approach in consciousness studies and cognitive science, its application to consumer research and service marketing remains nascent.

Within consumer neuroscience, electroencephalography (EEG) has emerged as the most widely validated and practically accessible instrument for capturing the real-time neural correlates of emotion, cognition, and engagement. A systematic review is the most reliable neural marker for distinguishing positive, approach-oriented states from negative, withdrawal-oriented states in consumer settings (Byrne et al., 2022). Complementary measures, including Cognitive Load Indices based on beta-to-alpha/theta power ratios and Engagement Indices reflecting active attentional states, together provide a multi-dimensional neurophysiological window onto the consumer's inner state during a service encounter. The application of these measures to the study of technology failure and human recovery in a phygital retail environment offers the possibility of moving beyond self-reported attitudes to capture the immediate, moment-by-moment neural dynamics of frustration, cognitive overload, disengagement, and regulatory relief that conventional instruments are structurally unable to detect.

The empirical context of the present study adds a further layer of theoretical significance. The research was conducted at the flagship phygital store of Digikala, Iran's dominant e-commerce platform, located in Tehran. This setting is particularly instructive because it embodies what may be characterized as an "emerging market digital paradox": a consumer population with high digital literacy and widespread e-commerce adoption operating within a trust environment shaped by structural uncertainties and informational asymmetries endemic to developing retail ecosystems. In such contexts, the physical store does not function merely as a distribution channel or an experiential showroom; it operates as a site of trust verification, where consumers seek to validate the credibility of digital brand promises through tangible, embodied encounters with products and personnel. Technology failure in this setting is therefore not simply an operational inconvenience— it is a threat to the foundational promise of the phygital encounter— and effective human intervention becomes an act of institutional credibility restoration rather than mere technical problem-solving.

2. Methodology

To penetrate the "black box" of the phygital service failure experience, this study employs a methodology that is as integrated as the phenomenon being investigated. We adopted a neurophenomenological research paradigm explicitly designed to bridge the explanatory gap between subjective experience and objective neurophysiology.

2.1. Research paradigm: Bridging the explanatory gap

This research is grounded in Varela's neurophenomenology research program (NRP), which advocates for a philosophically coherent integration of first- and third-person data. The core principle is "reciprocal constraints" or "mutual illumination", where each data stream informs and refines the analysis of the other in an iterative cycle. This is not a conventional mixed-methods study in which quantitative and qualitative findings are simply triangulated; instead, it follows a qualitatively driven design (QUAL+quan), in which the rich contextual insights from the phenomenological analysis provide an essential framework for interpreting the quantitative neural data. This approach allows for a deeper, more explanatory understanding of consumer consciousness, moving beyond prediction to uncover the structure and meaning of experiences.

2.2. Research context and participants

The study was conducted in a real-world "living laboratory": a flagship phygital store of Digikala, Iran's leading e-commerce retailer located in Tehran. This setting provided a naturalistic environment rich in technological touchpoints— interactive kiosks, experience zones, and digitally augmented product displays— that were central to our inquiry. The choice of Digikala is significant; trust in e-commerce platforms in emerging markets such as Iran is complex, often relying on "phygital" validation. Physical stores serve as tangible verification points for digital brands.

Consistent with the idiographic principles of Interpretative Phenomenological Analysis (IPA), which prioritizes depth of understanding over statistical generalizability, we employed a purposive, homogeneous sampling strategy. We recruited eight participants (anonymized as P01-P08) who shared a key set of characteristics: they had all recently visited the Digikala store and specifically interacted with the smart electronics section. This homogeneity allowed for a focused exploration of the shared essence of the phygital experience within a high-involvement product category.

Justification for sample size (N=8). While eight participants may seem small for quantitative studies, it is consistent with standard practices in IPA, where depth of analysis is prioritized over breadth. Data saturation was achieved with the eighth participant, as no new themes emerged regarding the core experience of technology failure and recovery. Furthermore, given the dual data streams (IPA interviews and EEG recordings), the analytical burden per participant is significantly higher than in single-method studies. The intensive, line-by-line coding of transcripts and the precise temporal alignment of EEG epochs require a manageable number of cases to ensure rigorous interpretation. Thus, N=8 is sufficient to capture the idiographic complexity of the phenomenon without compromising data quality or saturation.

A rich description of the participants' backgrounds and motivations (e.g., P01, a tech-savvy software engineer seeking "final physical confirmation"; P06, a first-time smartphone buyer seeking "simplicity and clarity") was compiled to enhance the transferability of the findings. These distinct motivations— utilitarian versus reassuring— provided varied baselines against which the impact of technology failure could be measured.

2.3. Data collection: The video-cued recall protocol

A central methodological challenge in neurophenomenology is the synchronization of rich experiential data with clean neurophysiological data. Concurrent "think-aloud" protocols, while capturing in-the-moment thoughts, severely contaminated EEG signals with speech and motion artifacts, rendering neural data unreliable. To overcome this, we

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designed and implemented an innovative two-stage Video-Cued Recall Protocol:

Stage 1. In situ experience capture through interviews. Participants navigated the phygital store and completed their shopping tasks in the study. Their entire experience was recorded from a first-person perspective using a discreet, wearable camera. No EEG was recorded during this stage of the experiment. This ensured maximum ecological validity, allowing authentic, unencumbered interactions with the environment.

Stage 2. Cued Recall Interview and EEG Recording. Immediately after the store visit, the participants were escorted to a quiet nearby location and fitted with a research-grade EEG cap. They were then shown a first-person video of their journeys. A semi-structured IPA interview was conducted, with the researcher pausing the video at key moments (e.g., interacting with a kiosk or speaking with an employee) to prompt a detailed recall of the thoughts, feelings, and sensations experienced at that exact instant.

Note on ecological validity. We acknowledge that collecting EEG data during video recall, rather than during the actual in-store encounter, introduces a limitation regarding ecological validity. The neural measurements reflect the re-experienced memory of the event rather than the immediate physiological response. However, the video cue serves as a powerful mnemonic device, activating episodic memory and enabling a far more granular and accurate recollection of the lived experience than a standard retrospective interview. This method allows for the synchronization of neural data with specific narrative moments, which is critical for neurophenomenological synthesis.

2.4. Data analysis

Data analysis followed a multistage, integrated process designed to honor the principle of reciprocal illumination.

Phenomenological analysis (IPA). The audio-recorded interviews were transcribed verbatim. Each transcript was then subjected to a systematic, multi-stage IPA process: (1) repeated reading and initial noting to immerse in the participant's world; (2) development of emergent themes capturing the essence of the participant's account; (3) clustering of these themes to identify superordinate themes that represent the core dimensions of the experience across all participants. To ensure rigor, the thematic structure was reviewed by two independent researchers to check for consistency in interpretation.

Neurophysiological analysis (EEG). EEG data were acquired using a research-grade electroencephalography (EEG) system. Continuous data underwent a standard pre-processing pipeline in MATLAB with the EEGLAB toolbox, including filtering, epoching, and artifact removal using Independent Component Analysis (ICA). Following the established literature in consumer neuroscience, three key metrics were calculated for each relevant epoch (Table 1):

- **Emotional valence.** Frontal Alpha Asymmetry (FAA) was calculated to measure the approach (positive valence) versus withdrawal (negative valence) motivational tendency.
- **Cognitive load.** A Cognitive Load Index (CLI) was computed, typically based on the power ratio of high-frequency bands (Beta) to low-frequency bands (Alpha, Theta).
- **Engagement.** An Engagement Index, often derived from beta/(Alpha+Theta) ratios, was used to measure the level of immersion and focused attention.

Table 1. The neurophenomenological lexicon: Key EEG metrics and interpretations

Metric	Basis of calculation	Key electrode sites	Psychological interpretation & key citations
Emotional valence (FAA)	Asymmetry in Alpha band power (8-13 Hz) between the left and right frontal lobes. Calculated as ln (Right Alpha) – ln (Left Alpha).	F3, F4, F7, F8	Higher values indicate greater relative left frontal activity, which is associated with approach motivation and positive emotional valence. Lower/negative values indicate greater relative right frontal activity associated with withdrawal motivation and negative feelings.
Cognitive load (CLI)	Ratio of power in higher frequency bands to that in lower frequency bands. It is commonly calculated as Beta (13-30 Hz) / (Alpha (8-13 Hz) + Theta (4-8 Hz)).	Midline frontal and parietal sites (e.g., Fz, Pz)	Higher values indicate greater mental effort, working memory load, and cognitive processing. Lower values indicate more intuitive or effortless information processing.
Engagement index	Ratio of Beta power to alpha power, or a similar formulation reflecting active attention.	Central and parietal sites (e.g., Cz, Pz)	Higher values indicate greater attention, immersion, and active engagement with the stimulus. Lower values indicate mind wandering, boredom or disengagement.

Neurophenomenological synthesis. The final and most critical stage was the synthesis. Using video timestamps as a common reference, the IPA themes and specific participant quotes were temporally aligned with the corresponding electroencephalography (EEG) epochs. We then employed a "pattern matching" protocol, systematically searching for the following:

- **Convergences.** Instances in which the qualitative narrative and quantitative neural data told a consistent story (e.g., a participant's report of frustration aligning with a neural signature of high cognitive load and negative valence).
- **Instructive divergences.** Instances where the two data streams appeared contradictory, signaling a more complex underlying phenomenon that required deeper interpretation (e.g., a report of enjoyment paired with a high cognitive load, suggesting a state of "flow").

To mitigate confirmation bias, the EEG analyst was blinded to the qualitative content of the interviews. The EEG indices were calculated independently before the synthesis phase. This separation ensured that the neural data was not selectively interpreted to fit the qualitative narrative.

Source: authors

Figure 1. The 'neural rescue': Human intervention reverses the neural signature of frustration in a phygital service encounter

The parallel coordinates plot illustrates the distinct neurophysiological signatures associated with the three critical phygital service encounters. The y-axis represents the normalized intensity of each metric, and the x-axis delineates the three core neurophysiological measures derived from EEG data. Emotional Valence was measured using Frontal Alpha Asymmetry (FAA), where higher values indicate positive approach-oriented states. The cognitive load was quantified using a Cognitive Load Index (CLI), which represents the level of mental effort. The engagement level was measured using an Engagement Index reflecting focused attention. The data revealed three contrasting experiential pathways. The 'Digital Dead-End' scenario (solid line), triggered by a technology failure, is characterized by a negative neural signature: strongly negative emotional valence (FAA≈−0.15), exceptionally high cognitive load (CLI=3.80), and a collapse in engagement (Engagement≈0.50).

In stark contrast, a competent 'Human Rescue' (dashed line) elicits a peak positive experience, marked by the highest positive valence (FAA≈0.31), significantly reduced cognitive load (CLI=1.80), and restored high engagement (Engagement=1.20). The 'Disruptive Intervention' (dotted line) serves as a boundary condition, showing how an incompetent human interaction recreates a neural signature similar to technology failure. This figure provides objective neurophysiological evidence for the 'Human Anchor' effect, demonstrating how effective human intervention can transform a moment of extreme customer frustration into a peak-positive brand experience.

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This iterative process, moving back and forth between lived experience and brain data, allowed for the generation of insights that would be inaccessible to either method in isolation.

3. Findings

An integrated analysis of phenomenological and neurophysiological data revealed a compelling narrative of failure and recovery. This narrative unfolds in two distinct acts: the experience of a technology-induced "Digital Dead-End" and the subsequent, transformative intervention of a "Human Anchor".

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3.1. The anatomy of a digital dead-end: Experiential and neural signatures of failure

A recurring theme in participants' journeys was the encounter with a non-functional or poorly designed technological touchpoint, which we term a "Digital Dead-End". This experience was not merely a minor inconvenience; it was a moment of profound frustration that fundamentally disrupted the customer journey.

Participant P01, a software engineer, vividly articulated this experience when interacting with an unresponsive touchscreen kiosk:

> "That touch kiosk was awful. I kept pressing it, but it did not work. You had to hit it ten times to open each page. I was so frustrated. I finally gave up and went to ask a salesperson."

This rich first-person account of frustration and abandonment finds a direct and powerful correlation in the EEG data. The moments corresponding to this interaction were marked by a distinct and consistent pattern across affected participants, which we identify as the "neural signature of frustration".

As shown in Table 2, this signature comprises three key components:

- **Negative emotional valence.** A sharply negative Frontal Alpha Asymmetry (FAA) score (mean: -0.15, SD: 0.08), indicating a strong withdrawal motivation and negative emotional state.
- **High cognitive load.** An extremely high Cognitive Load Index (CLI) score (mean: 3.80, SD: 0.45), quantifying the intense, yet fruitless, mental effort that P01 described. The participant expends significant cognitive resources but achieves no goal progress, a state often linked to "friction" in retail journeys.
- **Disengagement.** A very low Engagement Index score (mean: 0.50, SD: 0.12), providing an objective, neural marker for the subjective moment of "giving up." The brain disengages from a task when it deems the effort-to-reward ratio unfavorable.
- The powerful convergence between the phenomenological report ("I finally gave up") and the neurophysiological data (a collapse in engagement) demonstrates how a digital dead-end is not just a procedural halt but a cognitive-emotional crisis point. It represents a rupture in the "flow" of the phygital experience.

3.2. The human anchor as a regulatory mechanism

The narrative pivots dramatically when a competent frontline employee intervenes. These moments, thematically coded as "Human Rescue", represent the climax of the phygital service encounter. Human employees act as more than simple troubleshooters; they function as mechanisms for profound experiential recovery.

Table 2. Neurophenomenological analysis of technology failure and human Recovery

Scenario/ Theme	**Key participant quote**	**EEG signature (Mean ± SD)**	**Integrated interpretation**
Digital dead-end	"I was getting so frustrated... I finally gave up." (P01)	FAA: -0.15 ± 0.08 CLI: 3.80 ± 0.45 Eng: 0.50 ± 0.12	Convergence: The subjective narrative of frustration and abandonment is perfectly mirrored by the objective neural signature of negative emotion, intense and fruitless cognitive effort, and a definitive collapse of attention.
Human rescue	"If she hadn't been there, I would have just left." (P06)	FAA: 0.31 ± 0.06 CLI: 1.80 ± 0.30 Eng: 1.20 ± 0.15	Dynamic reversal: Human intervention performs a regulatory function, transforming the negative state of the Digital Dead-End into the most positive emotional state of the entire journey. It reduces cognitive load and restores deep engagement.
Disruptive intervention	"He broke my focus... I preferred to be alone." (P02)	FAA: -0.11 ± 0.07 CLI: 2.90 ± 0.35 Eng: 0.40 ± 0.10	Contingency: An incompetent or ill-timed human intervention recreates a neural signature of frustration. This demonstrates that the positive effect is not guaranteed by mere presence but is contingent on interaction quality.

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Participant P06, a less tech-savvy customer attempting to buy her first smartphone, described her experience of being rescued from confusion as follows:

> "I was fiddling with that device; I was confused. A young woman assisted me. In two minutes, she found what I had been looking for for ten minutes. If she hadn't been there, I would have just left right there."

The EEG data captured during these "Human Rescue" moments revealed a startling and complete reversal of the frustration signature. This human-led intervention elicited the most potent positive reaction recorded in this study.

The data (Table 2) show that this interaction was characterized by the following factors:

- **Peak positive emotional valence.** The highest average FAA score (0.31, SD: 0.06) observed in any context during the study, signifying an extremely strong positive emotional and approach-oriented state. This suggests that the relief provided by a human agent is affectively stronger than the joy of independently finding a product.
- **Reduced cognitive load.** A significant drop in the CLI to a low level (mean: 1.80, SD: 0.30), indicating that the employee's expertise transformed a confusing, high-effort task into an easy and fluent one. The employee effectively offloads the cognitive burden from the customer, facilitating a smoother cognitive passage.
- **High engagement.** A strong Engagement Index score (mean: 1.20, SD: 0.15) showing that the customer re-engaged deeply with the task and journey. The intervention did not end engagement but revitalized it, aligning with the "active attention" metrics.

This dramatic transformation from the most negative to the most positive neural state underscores the immense power of effective interventions. Employees do not merely solve technical problems; they actively regulate the customer's cognitive-emotional state, turning a moment of near-abandonment into a peak brand experience.

This bar chart complements the previous figure by providing a static visualization of the full range of neurophysiological responses observed for each key metric across the three critical service scenarios. Each horizontal bar represents one of the core metrics derived from the EEG data, with the x-axis quantifying the response intensity. The labeled data points correspond to the mean values of the key scenarios listed in Table 2. The chart visually represents the experiential gap between technological failure and successful human recovery.

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Source: Athors

Figure 2. The experiential spectrum: Range of neurophysiological responses across key service scenarios

The Cognitive Load Index (CLI) bar illustrates the wide spectrum of mental effort, anchored by the effortless 'Human Rescue' state (CLI=1.80) at the low end and the extreme cognitive strain of the 'Digital Dead-End' (CLI=3.80) at the high end. The Emotional Valence (FAA) bar captures the emotional polarity of the experiences, spanning from the strongly negative valence of the 'Digital Dead-End' (FAA=−0.15) to the peak positive valence of the 'Human Rescue' (FAA=0.31). These two points represent the most extreme negative and positive emotional states recorded in the present study. Similarly, the engagement bar quantifies the range of attentional states, bounded by profound disengagement during the 'Digital Dead-End' (Engagement=0.50) and the restored, high engagement of the 'Human Rescue' (Engagement=1.20). Collectively, the figure provides a quantitative summary of the transformative power of the 'Human Anchor,' demonstrating its capacity to regulate the customer's cognitive-emotional state from one extreme of the experiential spectrum to the other.

3.3. Boundary conditions: When human intervention fails

To provide a nuanced understanding, this analysis also identified instances in which human intervention was ineffective or even detrimental. The sub-theme "Disruptive Intervention" captures failed recovery. While initially treated as a boundary condition, this case required equal rigor in analysis to understand the limits of human intervention.

Participant P02, a UX designer attempting to analyze an AR feature, reported the following:

> "I was carefully examining the AR room when a salesperson came over and kept talking. He broke my focus. The information they provided was also incorrect. I preferred to be alone."

In this case, human intervention, being ill-timed and incompetent, generated a neural signature remarkably similar to that of the technology failure (Table 2). The experience was marked by negative emotional valence (FAA: -0.11, SD: 0.07), high cognitive load (CLI: 2.90, SD: 0.35) from processing unwanted and incorrect information, and a collapse in engagement (engagement: 0.40, SD: 0.10).

This crucial finding demonstrates that human presence is not a solution. The success of "neural rescue" is contingent upon the employee's competence, emotional intelligence, and situational awareness. An unskilled intervention can be as damaging as a broken kiosk.

4. Discussion: A model of human intervention as cognitive-emotional regulation

The findings of this study move beyond a simple description of events to reveal the underlying mechanisms of failure and recovery in the phygital environment. By synthesizing phenomenological and neurophysiological data, we propose a theoretical model that reframes the role of frontline employees from a service agent to an external regulator of the customer's internal cognitive-emotional state.

4.1. Synthesizing the findings

Empirical evidence demonstrates a clear two-act structure in the phygital journey. First, a technology-based service failure ("Digital Dead-End") induces a state of cognitive-emotional distress, objectively measurable as high cognitive load, negative emotional valence, and disengagement. In this state, the customer's sense of control and agency over their journey is lost. Second, a competent human intervention ("Human Rescue") can dramatically reverse this state, not only solving the problem but also creating a peak positive experience characterized by low cognitive load, high positive valence, and restored engagement.

This suggests that employees' roles transcend mere technical assistance. They are, in effect, performing Cognitive-Emotional Regulation.

4.2. Proposing the model of human intervention as a cognitive-emotional regulation mechanism

We formally propose a model in which the FLE acts as an external regulatory mechanism for the customer's internal state, which has been destabilized by a technology failure.

- **Antecedents.** The process is initiated by technology-based service failures. This failure acts as a trigger, shifting the customer from a state of autonomous navigation to a state of helplessness and frustration, characterized neurally by a high CLI and negative FAA. This aligns with the "negative deviations" in service quality.

- **Mechanisms.** The effectiveness of human intervention hinges on the deployment of two simultaneous regulatory functions.
  - **Cognitive regulation.** Employees leverage their expertise to reduce the customer's cognitive load. By diagnosing the problem, simplifying the complex technological interface, and providing a clear path forward, they transform a high-effort and confusing situation into a simple and effortless one for the user. This process directly reduces the high CLI values observed during failure.
  - **Emotional regulation.** Employees restore the customer's emotional equilibrium. The service recovery literature emphasizes the importance of distributive, procedural, and interactional justice. A technology failure is a procedural breakdown, but its cold, unresponsive nature makes it a profound failure of *interactional justice*. This technology is inherently incapable of showing respect, empathy, and concern. Human employee intervention— through active listening, expressing empathy ("I understand this is frustrating"), and offering assurance— directly restores this sense of interactional justice. This act of providing dignity and validation is the core mechanism that transforms negative emotional valence (negative FAA) into a peak-positive state.
- **Outcomes.** The successful execution of these dual regulatory functions leads to immediate outcomes of restored satisfaction and, more importantly, to long-term outcomes of enhanced brand trust and loyalty. The intensely positive emotional peak created by "Human Rescue" becomes a powerful affective memory. In line with the "affect heuristic" in decision-making theory, this positive emotional tag can be recalled in future interactions, serving as a mental shortcut for building brand trust.
- **Moderators.** The effectiveness of the model was not absolute. As the "Disruptive Factor" finding demonstrates, the outcome is moderated by employees' competence and situational awareness. Employees who lack the technical knowledge to regulate cognition or emotional intelligence to regulate affect will fail to execute the rescue and may even exacerbate their negative state.

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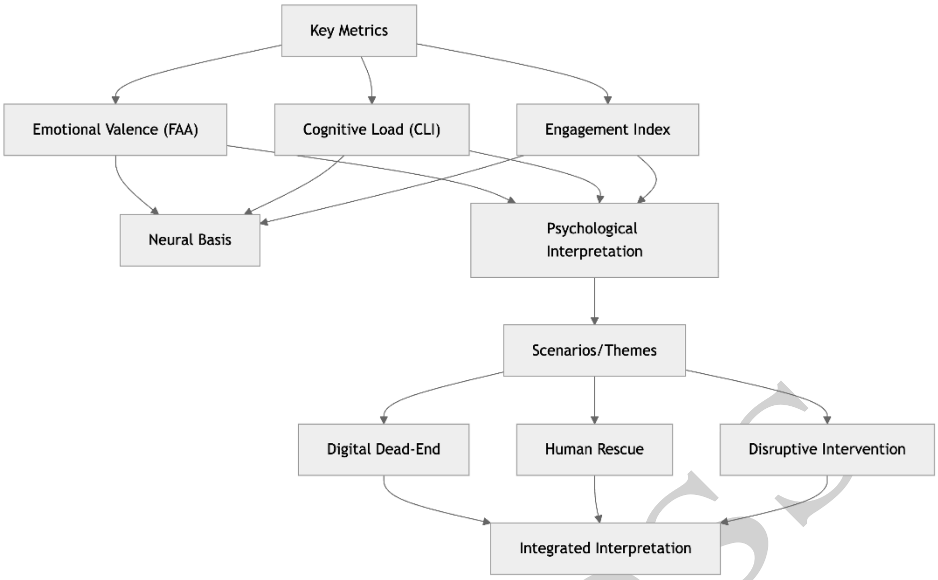

Figure 3. Conceptual framework for the neurophenomenological analysis

Figure 3 illustrates the multistage analytical framework that guides the integration of third-person neurophysiological data with first-person phenomenological data. The process begins with the quantification of three key metrics from the EEG recordings: Emotional valence (measured by Frontal Alpha Asymmetry, FAA), Cognitive load (Cognitive Load Index, CLI), and an Engagement index. Each metric is understood through its dual nature: its objective Neural Basis (the specific electrophysiological calculation) and its Psychological Interpretation (its established meaning in terms of subjective experience). This crucial interpretive step allows for the synthesis of neural data with qualitative findings, leading to the identification of three core scenarios/themes that define the critical moments of the phygital customer journey: The analysis of the distinct neural and experiential patterns within the 'Digital Dead-End', 'Human Rescue', and 'Disruptive Intervention' scenarios converges into a final Integrated Interpretation. This synthesis forms an empirical foundation for the theoretical model of human intervention proposed in this study. The framework visually represents the principle of "reciprocal illumination" which underpins our neurophenomenological approach, ensuring a transparent and rigorous pathway from raw data to theoretical insight.

4.3. The critical role of context: The "trust laboratory" in emerging markets

The power of this model is amplified in specific market conditions. The study was conducted in Iran, a market characterized by the "Iranian Digital Paradox": high digital savviness coexisting with a low-trust consumer environment. In this context, the physical store does not just function as a sales channel; it operates as a "Trust Laboratory" for the entire, predominantly online, brand.

Consumers enter this laboratory to physically verify the brand's digital promises by touching the products, seeing the quality, and gauging the company's substance. In this high-stakes environment, technological failure is a critical test of a brand's credibility. Therefore, human employees become the "chief scientists" in this laboratory. Their ability to expertly and empathetically manage failure provides the most powerful and tangible proof of a brand's overall trustworthiness and customer commitment.

This human-provided assurance is something that no amount of technological sophistication can replicate, making the "Human Anchor" a cornerstone of the phygital strategy in low-trust markets. The human element bridges the gap between the virtual third place and physical reality, ensuring that the brand evangelism potential of the metaverse and phygital platforms is not lost due to technical incompetence.

5. Conclusion

This investigates what happens— neurologically, experientially, and theoretically— when technology fails in a phygital retail environment, and what kind of human intervention is capable of transforming that failure into recovery. The findings, generated through a neurophenomenological synthesis of Interpretative Phenomenological Analysis and synchronized EEG measurement, converge on a clear and theoretically consequential answer. Technology-based service failures in phygital contexts do not produce mere inconvenience; they produce a distinctive and measurable neural signature of distress, characterized by strongly negative emotional valence, exceptionally high cognitive load, and a collapse of attentional engagement. This "Digital Dead-End" state represents a moment of genuine cognitive-emotional crisis— a rupture in the experiential flow of the customer journey that automated systems are structurally incapable of repairing, precisely because such systems lack the interactional capacity to acknowledge the customer's distress and restore their sense of agency and dignity. Conversely, competent human intervention— what this study terms the "Human Anchor" effect— produces the most powerfully positive neural state recorded across the entire study, surpassing even the affective quality of undisrupted autonomous navigation. This finding reframes the frontline employee not as a residual element of a pre-digital retail model but as an indispensable cognitive-emotional regulator whose value is paradoxically amplified, rather than diminished, by the increasing sophistication of the technological environment in which they operate.

The proposed model of human intervention as a cognitive-emotional regulation mechanism builds on and departs from prior work in important ways. It affirms the justice-theory tradition's emphasis on the centrality of interactional justice in effective service recovery (Russo et

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al., 2022), while demonstrating that in phygital contexts the interactional dimension is not one justice component among three but the constitutive mechanism through which all recovery value is delivered: it is the human capacity for empathy, situational awareness, and dignity-conferral that transforms a cognitively overloaded and emotionally withdrawn customer into one who is re-engaged, reassured, and affectively primed for positive brand evaluation. The study also contributes to the growing literature on phygital customer experience (Batat, 2022; Flavián et al., 2019) by identifying the conditions under which the phygital model's greatest structural vulnerability— its dependence on technological reliability— becomes its most significant opportunity: the moment of failure, handled well by a skilled human agent, generates a peak emotional experience more intense than any that frictionless technology alone is likely to produce. The boundary condition identified through the "Disruptive Intervention" theme is equally important theoretically, establishing that human presence is not in itself a regulatory resource— it becomes one only when accompanied by genuine competence, emotional intelligence, and situational sensitivity. An ill-timed or technically incompetent intervention can recreate the neural signature of technology failure, a finding with direct implications for how the relationship between technological and human service elements should be theorized and designed.

The Video-Cued Recall Protocol developed here addresses a genuine and longstanding tension in consumer neuroscience: the need to capture ecologically valid, naturalistic experience alongside artifact-free neurophysiological data. By separating the in-store experience from the EEG recording session and using first-person video footage as a mnemonic bridge, the protocol achieves high ecological validity at the experiential level while preserving the signal integrity required for reliable neural measurement. The principle of reciprocal illumination— drawn from Varela's neurophenomenological research program and operationalized here through systematic convergence and divergence analysis between IPA themes and EEG epochs— enables a quality of interpretive insight that neither method could generate in isolation. Where conventional consumer research must choose between the richness of subjective accounts and the objectivity of physiological measurement, the neurophenomenological synthesis pursued in this study treats that tension not as a methodological liability but as its primary analytical resource.

The contextual specificity of this study— its grounding in a flagship phygital store in Tehran, within the complex trust ecology of an emerging digital market— points toward broader implications for retail strategy in contexts where the physical store carries a burden of institutional legitimacy that extends well beyond its role as a point of transaction. In environments characterized by the "Iranian Digital Paradox", and by analogy in any emerging market context where e-commerce adoption outpaces consumer trust in digital institutions, the phygital store functions as what this study terms a "Trust Laboratory": a space in which the brand's credibility is continuously tested, verified, and either confirmed or undermined through the quality of human and technological interactions. In these settings, technology failure is not merely a service quality problem— it is an existential test of the brand's trustworthiness— and the frontline employee who handles that failure with competence and empathy becomes the most powerful trust-building instrument the brand possesses.

Conflict of interest

The authors declared no conflicts of interest.

Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc. This article was not authored by artificial intelligence.

Data availability

The dataset generated and analyzed during the current study is available from the author on reasonable request.

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