DESIGNING WHERE IT FEELS DEEPEST

MAPPING EMOTIONAL VALENCE TO IMPROVE HUMAN PERFORMANCE

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ABSTRACT

Design has always shaped how people feel. Yet in modern product creation, the emotional consequences of design decisions are rarely measured. They are inferred, assumed, or set aside. This paper argues that overlooking emotion is not only a design concern but a performance problem, and that the cost of getting it wrong is often invisible precisely when it matters most.

When a product creates friction, whether a seam that irritates, a fabric that traps heat, or a garment that fails in public, the cost is rarely just physical discomfort. It fractures attention, recruits effort the body would rather spend elsewhere, and quietly erodes the confidence that performance depends on. Conversely, when design gets it right, the product disappears and the user gets their focus back. That is not a soft benefit, it is a measurable shift in human capacity.

We frame these effects through the lens of compensatory control (Hockey, 1997). Under stress or load, people protect their primary goal by recruiting additional effort, so performance can look stable on the surface while the system pays a hidden price in physiological strain, narrowed attention, and downstream fatigue. Hockey calls this a latent decrement. A product that forces this trade-off does not simply annoy the athlete; it taxes the very system the product is meant to support.

This paper introduces the Convergent Affective Design Evaluation (CADE) framework, a multimodal methodology that locates these moments by triangulating across physiological, vocal, and behavioral indicators of emotion. Rather than relying on any single signal, CADE aligns multiple channels of the body's response, including heart rate variability, vocal prosody, and other measurable physiological inputs, into a single time-aligned composite of emotional experience, identifying not just whether a user liked something, but when a design element began to make or break their capacity to perform. Initial athlete testing shows that seemingly minor features, such as ventilation placement or seam construction, can produce rapid, measurable shifts in emotional and physiological state.

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The contribution is both methodological and philosophical: designing for emotional impact is a core performance intervention. This paper offers a practical framework that translates emotion into analyzable evidence, helping teams find the design opportunities that reduce load, protect confidence, and sustain endurance. Ultimately, the argument is simple. Designing for performance requires designing for feeling, and feeling can be mapped, studied, and used.

Keywords: emotional design; emotional valence; compensatory control; product design; affective neuroscience

1 INTRODUCTION

This research explores how the overlap of emotional response and physiological data can inform the way we design products, especially products worn on the body. Prior work in product-experience research shows that affect is not peripheral; it is tightly linked to how people evaluate products, form attachment, and continue or discontinue using them over time (Schifferstein & Zwartkruis-Pelgrim, 2008). This paper introduces a framework for identifying where design feels deepest by isolating the features that elicit the strongest emotional and physiological responses. When those responses are supportive, people move, focus, and endure. When they are not, performance quietly collapses, often without leaving an obvious trace.

The central move is to treat that quiet collapse as something we can detect. Psychophysiological indicators such as cardiac activity have been shown to meaningfully model user-experience states, offering a complementary layer to self-report when assessing stress, engagement, and interaction quality (Čertický et al., 2019). By capturing both what users feel and how their bodies respond to products, we can locate opportunities for innovation that genuinely tend to human needs. This methodology turns how it feels into usable evidence, allowing teams to pinpoint the exact moments a product supports performance or undermines it. When those moments are mapped to specific features, designers can make targeted changes that reduce cognitive load, protect confidence, and sustain physical endurance.

We invite the reader to hold a larger possibility in mind throughout. If we can reliably see where a product helps a body settle and where it forces a body to fight, we are no longer only refining objects. We are designing for the conditions under which people can be fully present in their own effort, and that is a horizon worth reaching for.

2 CONTEXT AND BACKGROUND

Design has always been intertwined with emotion. People develop deep attachments to certain products, particularly those they keep in extended contact with, such as apparel, footwear, and furniture. These products can spark joy and security or trigger frustration, sadness, or fear (Schifferstein & Spence, 2008). Emotional design theory holds that products engage us at visceral, behavioral, and reflective levels, and that fulfilling experiences across all three foster positive emotion (Norman, 2004). Movements such as Positive Design extend this further, arguing that design can be a deliberate instrument for human flourishing and well-being (Desmet & Pohlmeyer, 2013).

Physical performance depends on a body that can breathe and move without constant negotiation. Mental performance depends on attention that is not fractured by irritation, self-consciousness, or threat. When a product repeatedly creates moments of stress, it does not merely irritate the user. It taxes the nervous system, disrupts focus, and can shape whether a person returns to the activity at all. Prior research in design psychology shows that strong product attachments are dominated by positive emotion (Schifferstein, 2008), while negative experiences, especially discomfort, product failure, and public embarrassment, can leave a lasting emotional residue that undermines trust and confidence.

2.1 A mechanism for the hidden cost: compensatory control

To explain why a small design flaw can carry an outsized cost, we draw on Hockey's cognitive-energetical framework of compensatory control (Hockey, 1997). Developed to account for human performance under stress and high workload, the model makes a deceptively simple observation: primary task performance is remarkably stable under stress, and that stability comes at a cost, elevated physiological activation and subjective strain. People protect what matters most by mobilizing effort, and that effort has a price.

Crucially, the price is often hidden. Hockey argues that even when overt performance holds, the strain of protecting it surfaces elsewhere, as the neglect of secondary tasks, a shift to simpler and less flexible strategies, increased sympathetic activation, and fatigue after the fact. He names this a latent decrement: a compromised internal state that stays invisible under normal conditions but constrains the system's capacity to absorb anything further. The model also distinguishes the modes by which people cope. In active coping, demands are met with effort but little distress. In a strain mode, performance is maintained, but at a steep and sustained physiological cost. In passive coping, the goal itself is downgraded or abandoned. The shift that is concerning is the slide from strain into disengagement, where the athlete, worn down by accumulated cost, simply stops showing up.

Reframed this way, a poorly placed seam or a constricting, heat-trapping garment is exactly the kind of disturbance Hockey describes: an external perturbation that pulls resources away from the task. The athlete keeps running, so her split time may look untouched. But she is now paying a compensatory cost, and that cost is the very thing conventional product feedback fails to capture. Our method is, in effect, an instrument for making latent decrements visible in the lived experience of a product.

2.2 Reading the body: heart rate variability as a window on regulation

If compensatory effort leaves a physiological signature, heart rate variability (HRV) is one of the most informative places to look for it. The neurovisceral integration model (Thayer et al., 2012) describes a flexible cortical-subcortical network, centered on the ventromedial prefrontal cortex and amygdala, that exerts top-down inhibitory control over the heart. When that control is intact, the heart shows rich beat-to-beat variability, the marker of a system that is regulated, adaptable, and at ease. When perceived threat draws prefrontal regions offline, this inhibition is released, sympathoexcitatory circuits (the stress pathways that mobilize energy for action) are disinhibited, and HRV falls. This gives our physiological measure a clear interpretive frame. A drop in HRV during a product experience is not noise; it is a reading on how hard the regulatory system is working, and a sign that the body has shifted toward a more stress-loaded, less flexible state.

Thayer's account dovetails with Hockey's: both describe a system that protects its goals through top-down control, and both warn that when that protection is sustained, the unrelieved load accumulates, an idea Thayer connects to allostatic load and long-term wear on the body.

3 MATERIALS AND METHODS

Eight women took part in the study. For this paper, the focus was on session in which participants recounted clearly differentiated product experiences, distinct moments of both distress and relief, since these contrasts are precisely where a convergence-based method can be most clearly demonstrated. The interview presented below is the single clearest case of this pattern offered as an illustrative example rather than a representative average.

This research uses a multimodal approach to capture users' emotional responses to products in a controlled but familiar environment. Participants interacted with, or recalled experiences of, products while their narrative, vocal expression, and cardiac activity were recorded together. The design deliberately combines a subjective channel (what the participant says and how they say it) with an objective physiological channel (how the body responds), so that each can be read against the other.

Cardiac activity was recorded with a Polar H10 ECG chest strap, from which heart rate variability was derived as an index of autonomic regulation (Thayer et al., 2012). Emotion is reliably accompanied by changes in cardiac and vocal activity (Čertický et al., 2019; Kreibig, 2010), and the voice in particular carries a rich, involuntary trace of affective state. Vocal expression was analyzed acoustically in Praat (Boersma & Weenink, 2024), extracting prosodic features such as fundamental frequency and its variability, intensity, and measures of voice quality (for example jitter and shimmer) that shift with arousal and emotional strain. Interview narrative was transcribed and coded so that specific product moments could be located on a common timeline.

The core methodological shift is simple but consequential: build a single, time-aligned dataset that overlays emotional indicators with physiological response. The result is not a list of reported feedback but a map of emotional magnitude across the product experience. This builds on established practice in human-computer interaction, where psychophysiological signals are combined with subjective report to model user-experience states (Čertický et al., 2019). Applied to design research, the framework supports a more objective synthesis of emotional response by linking what people say to measurable, time-stamped changes in the

body (Figure 1). Importantly, no single metric or method is relied upon for interpretation alone.

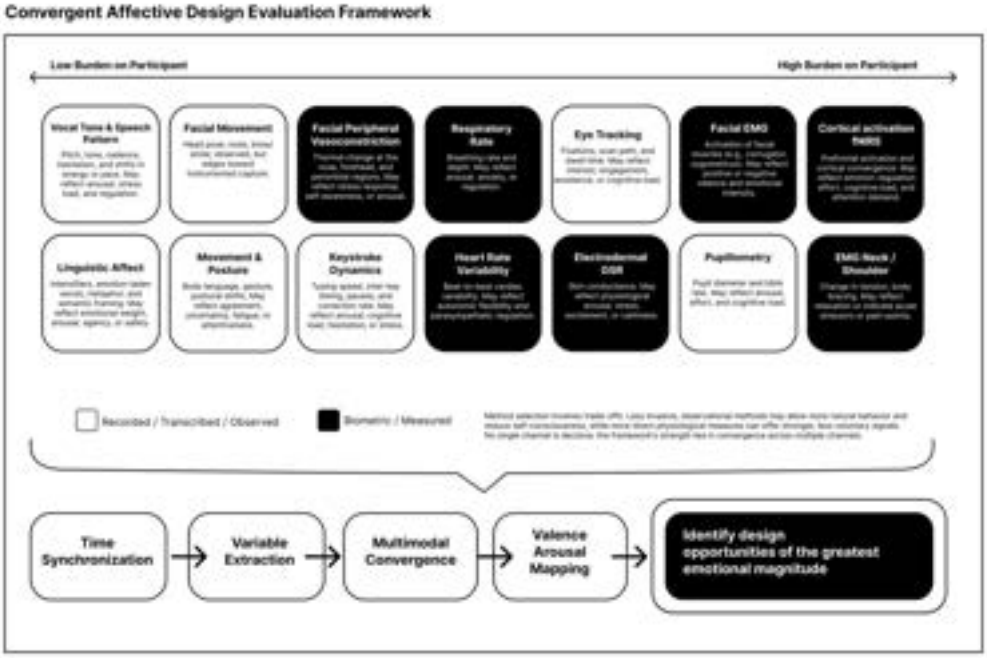


Figure 1. ***The Convergent Affective Design Evaluation (CADE) framework.*** *CADE locates the moments in an experience where a design carries the greatest emotional and performance consequence. It draws on a broad, substitutable menu of affective signals, arranged (upper panel) from unobtrusive, observed signals to more obtrusive, directly measured physiological ones; the signals shown are illustrative, not prescriptive. No single signal is treated as decisive. Instead, convergence is the core mechanism: when independent signals agree at the same moment, that agreement gives the moment its weight. The lower panel shows the pipeline, time synchronization, feature extraction, multimodal convergence, and valence arousal mapping, culminating in the design opportunities of greatest emotional magnitude.*

4 KEY FINDINGS AND INSIGHTS

Initial findings show clear patterns in how design elements trigger emotional and physiological response. Even when participants were recalling a single product experience rather than living it in the moment, they exhibited a wide range of affect. When a product caused discomfort or failed, and particularly when it failed in public, participants' accounts carried the markers of fear and anger, and these moments coincided with pronounced shifts in cardiac activity.

One insight stands out: seemingly minor design issues can provoke outsized reactions. A poorly placed seam that irritates does not only create physical discomfort. It creates a distraction that fractures focus and temporarily narrows cognitive capacity, the textbook signature of a latent decrement. From a performance standpoint that is far from trivial. It is the difference between being fully in it and being repeatedly pulled out.

4.1 Multimodal emotional response in an athlete interview

In one interview, a participant described a range of pain points across sports bras, from irritation to fit to heat management. Read as a transcript alone, many of these concerns could have been weighted as roughly equal. The multimodal data told a different story. When she described feeling trapped in a sweaty sports bra she hated (Bra A), her language was direct, but

the physiological and vocal signals were disproportionate to the rest of the conversation. As she spoke about the constriction she felt and the sweat-logged fabric, her vocal-acoustic profile shifted in ways consistent with elevated arousal and strain, while her heart rate variability dropped to 24ms.

Read through the neurovisceral lens, that HRV reading is a window onto autonomic regulation. A drop of this kind reflects reduced parasympathetic flexibility and a shift toward a more stress-loaded state, especially when it occurs acutely during the recall of a specific event (Thayer et al., 2012). It suggests this was not a passing annoyance but a moment that meaningfully engaged threat and a sense of lost control, an interpretation reinforced rather than asserted, because the vocal signal and the narrative pointed the same way at the same instant (Table 1).

Table 1. Vocal-acoustic and cardiac comparison, Bra A versus Bra B

Measure	Baseline 00;00;00;00 - 00;10;04	Bra A (distress) 00;00;05;00 - 00;05;35;08	Bra B (relief) 00:00:53:22 - 00:01:27:22
F0 variability (SD, Hz)	38.2	48.48	29.86
Jitter, local (%)	1.81	2.07	1.62
Shimmer, local (%)	13.1	15.38	11.26
Harmonics-to-noise ratio (dB)	11.8	7.93	16.75
Heart rate variability (RMSSD, ms)	33	24	41

Note: Voice-quality and pitch measures were extracted in Praat (Boersma & Weenink, 2024) using autocorrelation pitch tracking with a 75–500 Hz analysis range; jitter, shimmer, and harmonics-to-noise ratio are from the Praat Voice Report. Intensity is not reported because the recording was not calibrated for absolute sound pressure level. The fraction of unvoiced frames was comparable across segments (A = 46.4%, B = 47.7%), indicating that differences in voice quality are not attributable to one segment carrying a noisier signal. Heart rate variability (RMSSD) was derived from Polar H10 ECG over the corresponding segment.

Each session was video-recorded and reviewed to confirm that changes in prosody and heart rate variability were not attributable to shifts in posture, body position, or other movement-related factors. Participants remained in a consistent seated position throughout, supporting an affective rather than postural interpretation of the observed differences. To protect participant privacy, this footage was used solely for internal verification and is not reproduced here.

A baseline was also captured for each participant at the start of the session, while they read an emotionally neutral, deliberately bland control script. This baseline provides a within-participant reference point against which the distress and relief segments can be compared, helping to distinguish emotionally driven change from each individual's ordinary speaking and cardiac signature.

Later in the same interview, she spoke about a sports bra that finally relieved the pain point she had described (Bra B). As she described generous front perforations that let air reach the sternum and chest while running, her vocal cadence softened and her account turned warm and unhurried, the signature of a body that had downshifted out of threat. The implication is not that one bra is universally good and another bad, but that specific design features can rapidly change emotional and physiological state in ways that are measurable and actionable.

This is where the methodology becomes performance-relevant. Had the interview been evaluated on transcript alone, the participant's list of pain points might well have been treated as equal in weight. Without clear prioritization, a design and development team would likely have spread incremental improvements thinly across many features, or addressed only those the budget and timeline allowed. By layering cardiac response and vocal-acoustic analysis onto the narrative, we can identify the single most important opportunity with far greater confidence. Here the data surfaced the priority unambiguously: the sweat-trapped, constricting experience was the dominant driver of distress, and therefore the most impactful opportunity to pursue. Across the session, the most intense moments were consistently the ones that stood out across both physiological and self-report channels, helping translate lived experience into clear design direction. The same convergence pattern, physiological and vocal signals intensifying together at moments of narrated distress, recurred across the differentiated sessions, indicating that this interview illustrates a repeated dynamic rather than an isolated instance.

4.2 Implications

These findings show that when traditional design research is paired with a dimensional view of emotion and grounded in physiological signal, designers gain a far sharper view of what truly matters in lived experience. Self-report remains essential, but on its own it can flatten nuance, making many pain points sound equally urgent while masking which moments are actually driving distress, distraction, or withdrawal. Combining interviews with physiological indicators and brief valence-focused tools (for example the Self-Assessment Manikin; Bradley & Lang, 1994) lets us identify the highest-leverage opportunities for innovation, the places where a single feature can meaningfully restore comfort, confidence, and control.

In performance contexts, that clarity is a practical advantage. It helps teams prioritize the changes that protect focus, reduce strain, and sustain endurance, especially in high-exertion situations where body and mind are already operating near their limits. In Hockey's terms, it tells us where a product is forcing an athlete into a costly strain mode, and where a better design lets her return to low-cost, active engagement, the state in which she can give the most while losing the least.

5 CONCLUSION

Design decisions leave traces in the body. In this work, those traces become legible. By synchronizing interview narrative with cardiac and vocal-acoustic indicators, we move from generalized preference statements toward a precise understanding of when a product supports human capacity and when it quietly drains it. The central finding is not simply that products evoke emotion, but that the most consequential design problems are often the ones a transcript

alone would never elevate. When emotional valence and physiological strain converge on a single feature, the design priority becomes unmistakable. This gives designers a practical, repeatable way to protect what matters most in performance: attention, confidence, and the will to persist.

The implications reach well beyond sport. In a broader landscape where stress, anxiety, and cognitive fatigue are increasingly common, the everyday products carried through daily life have real power to either amplify strain or restore regulation. A drop in HRV during a product experience marks a moment of diminished autonomic flexibility, a body shifting into a more stress-loaded state; left unaddressed, such micro-stressors may accumulate into meaningful physiological burden over time (Thayer et al., 2012). Conversely, when design reduces irritation, improves comfort, or removes the threat of failure, the nervous system can settle and the user regains bandwidth for the task at hand. Affective experience, as a growing body of work suggests, is not a cosmetic layer of interaction but a pathway through which the things around us shape well-being (Kreibig, 2010; Shu et al., 2018).

So it is worth dreaming a little about where this leads. Imagine product testing that listens to the body as carefully as it listens to opinion. Imagine design teams who can see, in advance, which detail or material or feature will let an athlete stay present in her own effort, and which will quietly pull her out of it. Imagine performance products evaluated not only by what they let people do, but by how steady they let people feel while doing it. This is the larger invitation of the work: to treat the body's quiet signals as design intelligence, and to build things that give people their attention back.

Ultimately, this paper argues for a redefinition of performance design. Performance is not only strength, speed, or endurance. It is also the ability to stay steady inside the experience, to hold attention, to feel safe enough in one's own body to keep going. The methodology presented here offers a way to design toward those outcomes with greater clarity, accountability, and compassion. It is a call to treat how it feels not as a subjective footnote, but as evidence, and as a primary lever for improving human performance in the moments that matter most.

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serves as Adjunct Faculty in the College of Design at the University of Oregon, teaching design research, sports product design, and innovation.

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