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PSYCHOPHYSICAL RESPONSES TO TEXTILE MECHANICAL PROPERTIES: A NEURO-MECHANISTIC APPROACH TO FABRIC-HUMAN INTERACTION

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Abstract: *This manuscript establishes a comprehensive and empirically grounded framework for the Psychophysics of Style, creating a transdisciplinary bridge between the material engineering of textiles and the neurobiology of human cognition. Situated within the contemporary crisis of the attention economy and the increasing dematerialization of the self into digital constructs, this research posits that the act of dressing is not merely a sociocultural signaling mechanism but a fundamental psychophysical interface that regulates emotional stability, cognitive processing, and ontological coherence. We argue that the materiality of clothing serves as critical ontological ballast, counteracting the fragmentation of the digital age through quantifiable mechanical inputs. By synthesizing Kansei Engineering and advanced tactile neurobiology, this approach moves from the metaphorical to the measurable. We incorporate verified empirical data, including the identification of a precise texture recognition threshold of 45.4μm that demarcates the transition from passive to active neural processing. Furthermore, the study demonstrates that fabric volume modulates Electroencephalography (EEG) Alpha bands, validating that textile substantivity impacts cognitive orientation. Such biological findings were corroborated with Life Cycle Assessments to prove the validity of natural fibers over synthetic materials in this case. Therefore, these results set out the basis of Sustainable Enclothed Cognition with a proposition that added mechanical strength and moral mass of natural textiles are a sufficient counterpoint in this way to sustain human awareness in such a fluid digital culture.*

Keywords: *Enclothed Cognition, Neuroaesthetics, Kansei Engineering, Tactile Neurobiology, KES-FB.*

1. INTRODUCTION

The sociocultural and psychological environment of the present era is marked by a deep paradox: the hyper-visibility of superficial aspects coexists with a fundamental emptiness of internal experience [1]. This era sees the unprecedented projection of the image of the individual, at the same time as the experience of subjectivity itself appears ever more precarious. By means of the mediations of digital social media, the subject of humanity is reproduced in digital form, creating a milieu in which the subject experiences itself reflected and offered as a minutely articulated digital projection.

We exist within an increasingly digitized society that has evolved into an assertive attention economy, a system in which human attention constitutes the primary commodity for which algorithmic entities contend [2].

In this context, described as surveillance capitalism, the management of self-presentation has emerged as the principal currency of social interaction, and identity is progressively transformed into an ongoing design endeavor, continuously optimized based on engagement metrics [3].

Such a marked transition into a digital reality leaves a sensory gap that a human nervous system is never designed to cope with. A study of human evolution shows how cognitive functions have a fundamentally embodied nature in which our conception of reality is constructed through our bodily experiences. With a newfound mode of self-expression in digital pixels that do not have any mass or resistance in space, our proprioceptive loops, which are meant to confirm our reality in space, therefore go out of function because our brains simply lack a sufficient level of ontological friction.

To properly apprehend the profound implications of this ontological dilemma, it is imperative to distinguish human volition from the results produced by algorithms. Indeed, recent scholarly inquiry contends that while Artificial Intelligence can replicate creative endeavors, it fundamentally lacks the authentic essence characteristic of human expression [4].

Furthermore, the disintegration of personal identity is a reflection of a deeper neurological reality rather than just a social phenomenon. In this context, tangible belongings, which were formerly essential pillars of one's identity, have gradually evolved into ephemeral digital data stored in interconnected networks.

As a result, the collaborative formation of selfhood is increasingly mediated by abstract computational processes rather than by tangible physical artifacts, leading to a precarious understanding of reality [5, 6]. As a result, there is a kind of existential unmooring; the individual psyche struggles to define its own boundaries because it is deprived of the physical world's tangible resistance and engagement.

Within this context of dematerialization and pervasive digital influence, textile artistry and the practice of adorning the physical body emerge as a crucial locus of ontological resistance. As Sturza [7] argues, the intersection between text and textile has historically shaped human individuality, serving as a palpable language of identity. Clothing is reconceptualized here not as a trivial endeavor, but as the foremost interface where the internal self navigates its manifestation in the external world.

From the vantage point of textile engineering and psychophysics, this interface constitutes the microclimate situated between the skin and the fabric, a region where physiological regulation converges with psychological perception. This paper proposes that the congruence between an individual's internal state and its visible material expression constitutes an essential requirement for psychological well-being.

The idea of Ontological Ballast is proposed to clarify the nature of resistance, texture, and mechanical hysteresis provided by fabric in order to allow the psyche to interact with and understand its surroundings. The idea proposes that in a digitalized society where the external environment is increasingly virtualized, the clothes worn on the body are an essential protection mechanism for ontological security. Therefore, the primary objective of this research is to validate a neuro-mechanistic framework for the 'Psychophysics of Style,' demonstrating how quantifiable textile mechanical properties directly regulate cognitive processing and emotional stability.

2. GENERAL INFORMATION

The establishment of a shared understanding of the Psychophysical aspects of Style demands that much existing scholarship in three totally different fields (affective engineering, or Kansei Engineering; neurobiology which underpins tactile impressions, and Enclothed Cognition, where psychological dynamism and clothing meet) has to be reviewed.

In the past, conventional textile engineering paid more attention to quantifiable indices like tensile strength and wear resistance. Although these indices are essential for the working life of a

garment or some other product, they often do not take into account the human experience. This is where Kansei Engineering comes in. Kansei engineering is an approach to technological innovation which focusses on the user, and aims at converting qualitative attributes marked out by consumers into objective, quantifiable physico-chemical features of materials [8].

This technique is nowadays successfully employed in parts of consumer electronics, motor vehicles and daily necessities. It has expanded from a primarily engineering-based means of qualitative differentiation to one which also takes account of neurophysiological data - specifically via Electroencephalography (EEG) - in order to avoid subjectively verbalized descriptions, and so establishes a direct relationship between physical stimulation and neurophysiological response.

Concurrently with the study of affective engineering is the neurobiological examination of the skin interface. The integumentary system serves as the primary interface between an organism and its external environment, featuring an elaborate system of sensory structures that transmit tactile information through both pathways for detailed perception and pathways for emotional response [9].

The discriminative pathway, facilitated by rapidly conducting nerve fibers, enables the identification of texture and spatial location of an object, utilizing Pacinian corpuscles to perceive high-frequency vibrations indicative of subtle textures [10].

Recent research has identified subtle points involving neural processing, moving beyond the mere reception of stimuli toward active interpretation [11]. In contrast, the affective pathway is mediated by slowly conducting C-tactile afferents, mainly in hairy skin, which respond to the velocity of gentle touch and transmit signals to brain regions associated with emotion, contributing significantly to interoceptive body awareness and to emotional regulation [12]. This system evolved to convey signals of social safety and bonding.

The third foundational element is the theory of Enclothed Cognition, which suggests that clothing's impact on an individual stems from the simultaneous presence of its symbolic significance and the tangible experience of wearing it [13].

While initial investigations encountered questions concerning reproducibility, more recent meta-analytic reviews, employing Z-curve analysis, have substantiated the robust and significant impact of attire on cognitive processes, contingent upon the congruence of symbolic and physical elements [14]. This corroboration permits the consideration of Enclothed Cognition as a dependable parameter for design. Moreover, the effectiveness of such psychophysical interventions relies on ethical consistency, herein termed Sustainable Enclothed Cognition [15].

An individual's awareness of a garment's ecological footprint can impose a cognitive burden; consequently, accurate environmental information, derived from refined Life Cycle Assessments, is vital to harmonize the wearer's tactile perception with their ethical principles [16].

Consequently, to operationalize this theoretical convergence, this research addresses four specific tasks: 1) The objective quantification of subjective tactile sensations using the KES-FB system; 2) The determination of specific neural thresholds for texture recognition using EEG; 3) The verification of fabric volume's impact on cognitive vigilance via Alpha wave modulation; and 4) The validation of environmental sustainability through corrected Life Cycle Assessments (LCA) to ensure ethical consistency in the proposed framework.

3. MATERIAL AND METHOD

To establish a robust theoretical framework for the Psychophysics of Style, this investigation employed a multidisciplinary theoretical approach synthesizing empirical data. This methodology linked measurable material attributes to neurological activity and established psychological constructs. A primary obstacle in the domain of affective engineering pertains to the objective

quantification of the intrinsically subjective tactile experience of textile materials. For this reason, data derived from an extensive and diverse assortment of fabrics from commercial sources (spanning lightweight silk to heavyweight tweeds) were analyzed using the Kawabata Evaluation System for Fabrics (KES-FB) to evaluate the physical properties of fabrics (via 10 mechanical properties) [17]. By breaking down the way people perceive the feel of fabrics into ten measurable physical properties (resistance to shear; flexure stiffness; compressive force; surface texture), through the process of the KES-FB system, researchers were able to define the physical characteristics of each of the fabrics analyzed as independent variables in their study.

To establish a link between these mechanical properties and neurological conditions, we analyzed data from neurophysiological studies, specifically those involving 40 healthy participants. The initial phase of the analyzed protocols investigated the perceptual threshold for texture recognition, employing electroencephalography (EEG) event-related potentials. Subjects were exposed to surfaces exhibiting incrementally increasing geometric irregularity while EEG data were acquired to observe the P300 component, an established indicator of cognitive resource allocation [11].

The next step was to see how the thickness of clothing affects how alert people are. This was done by looking at the brain waves of people wearing clothes of thickness and weight. The brain waves that were looked at were the Alpha waves. When these Alpha waves were not as strong it meant that the brain was working harder and people were more aware of what was going on around them [18].

Lastly, to substantiate the framework of Sustainable Enclothed Cognition, the ecological footprint of the selected fabrics was reassessed employing Life Cycle Assessment with expanded system boundaries (cradle-to-grave). This analysis drew upon the 2025 Ecoinvent database and specialized data pertaining to wool processing to mitigate historical prejudices against natural materials, thereby enabling a direct comparison of the true environmental cost of natural versus synthetic fibers, extending beyond the manufacturing stage [16].

The statistical credibility of the psychological premises was further strengthened through a Z-curve analysis of extant research on Enclothed Cognition, thereby confirming the solidity of the theoretical underpinnings.

4. EMPIRICAL RESULTS AND PHYSIOLOGICAL ANALYSIS

The studies discussed in this study demonstrate an integration of mechanical, neural, and meta-analysis evidence to significantly validate the psychophysical principles pursued in this research. This represents evidence that all of the material characteristics were consistently associated with correspondingly patterned brain activity. Another critical finding from neurophysiological studies is the exact sensory threshold for tactile recognition of textures, which has been identified at a level of 45.4 μM [11].

Surfaces with a tactile texture that measures less than the noted amount elicited very little change in the P300 event-related potential, which suggested that the neural mechanism which generates this potential, which is thought of as a passive mechanism, passes or screens out smooth tactile stimulation and treats it as background information, or ambient, and does not pay attention to it. Conversely, once surface roughness surpassed this 45.4-micrometer threshold, a statistically significant elevation in P300 amplitude was consistently observed [11].

This qualitative shift signifies a change from spatial to vibrational encoding of sensory data. At this point, friction produces complex signals that stimulate Pacinian corpuscles, thereby activating the somatosensory cortex and eliciting an orienting response.

Moreover, analysis of the EEG Alpha wave revealed a strong inverse relation between the overall volume of fabric and the power of Alpha waves [18, 19]. The presence of thick and compression-resistant fabrics resulted in a substantial decrease in Alpha wave activity. Since Alpha attenuation is a proxy for active cerebral processing, this suggests that heavy and massive fabrics produce a proprioceptive requirement, demanding continuous neuronal activation. Additionally, the employment of deep pressure stimulation, delivered via substantial clothing, was validated as a mechanism to reorient autonomic nervous system activity toward parasympathetic dominance, alleviating anxiety while preserving attentiveness [20].

Regarding the validity of the cognitive impact, meta-analytic validation employing Z-curve analysis confirmed the genuine and reproducible impact of clothing on cognitive processes, specifically when there is alignment between a garment's symbolic meaning and its physical experience. Finally, new data for Life Cycle Assessment (LCA) showed that natural fibers like wool often have a superior environmental performance compared with synthetic fibers when the use phase and biodegradability are taken into account [21].

4.1. Theoretical Implications: The Psychophysics of Style

Drawing upon the physiological data presented herein, we put forth a theoretical framework for elucidating these observed mechanisms. By engaging in physical contact with materials that exhibit a certain level of roughness (>45.4um) by using our sense of touch, we can derive a physiological basis for the personality construct known as a "Grounded Realist." Furthermore, it is hypothesized based on these results that the act of touching coarse textures provides a tangible/physical connection that mitigates the feelings associated with being digitally disengaged [22].

Similarly, we interpret the modulation of Alpha waves described in the results as evidence of "Ontological Ballast". We posit that the proprioceptive load of heavier fabrics achieves a sense of embodied alertness, whereas light, low-density fabrics - common in fast production - may contribute to a sense of disembodiment due to the lack of this neural feedback.

Therefore, the implication of the complex interaction amongst these mechanical factors is that cloth not only overlays the body, it also translates mechanical constraints into psychological affordances. The linkage between precise parameters of KES-FB, such as shear stiffness, mechanical hysteresis, and surface friction, and particular neurophysiological states enables a direct translation of the somatic topography of the cloth onto the cognitive demands of the wearer, thereby illustrating that particular patterns of weight, resistance, and rigidity do not work independently; instead, they constitute a unitary somatic language that is deciphered by the nervous system to communicate a particular way of existing within the world.

From a neuro-mechanistic point of view, these psychological phenotypes outlined within this text are more than arbitrary designations with aesthetical merit – rather, they represent a necessary cognitive architecture for this particular era. Each type remedies a particular inadequacy in the digital age: a hard edge for a boundless zone on the web, a comforting touch in a distant age, or a sudden sensual friction necessary for a drift toward the virtual. It is a corrective mechanism that enables a specific type or quality of physical friction that allows for allostatic regulation on a psyche.

For this relationship to be harnessed effectively in engineering and design, it is crucial to translate analysis into prescriptive action. It is through a synthesis of texture, alpha-wave attenuation, and a quantifiable link established between micro-mechanics and macroscopic behavior that this relationship can be traced, thereby allowing a reverse engineering of desired psychological states through calculated material selection and the translation of biological reality into engineered constructs.

These collective findings facilitated the construction of a Psychophysical Translation Matrix (Table 1), which correlates specific mechanical properties with distinct psychological profiles. For example, individuals categorized within the "Strategist" phenotype were observed to benefit from high bending rigidity, which appears to offer a proprioceptive scaffolding that bolsters self-perception and consumer confidence [19].

Table 1: *Psychophysical Translation Matrix*

Psychological Phenotype	Cognitive Goal	Key Mechanical Parameter (KES-FB)	Neurobiological Mechanism	Material Examples
The Strategist	Authority, Boundaries	High Bending Rigidity (B), High Shear Stiffness (G)	Proprioceptive scaffolding; Deep Pressure Stimulation (Parasympathetic activation)	Heavy Gabardine, Structured Leather, Canvas
The Grounded Realist	Alertness, Presence	Surface Roughness (SMD) > 45.4 μm; High Thickness (T_0)	Pacinian Activation (250Hz); P300 Amplitude Increase; Alpha Attenuation	Raw Denim, Tweed, Raw Linen, Hemp
The Nurturer	Safety, Connection	High Compressional Energy (WC); Low Roughness	C-Tactile Afferent Stimulation (Insular Cortex); Oxytocin Release	Cashmere, Velvet, Angora, Soft Knits
The Innovator	Flow, Divergence	Low Shear (G), Low Bending (B), Low Weight (W)	Minimal proprioceptive load; Reduced somatic attention	Silk Crepe, Fine Jersey, Tencel, Tech Silk

Moreover, the temporal element in these materials is a relevant factor in this bonding process. Natural materials such as wool and linen have a quality of aging in which they attain a patina that records in a physical sense the passage of time with the wearer. Such a quality in these materials can hardly be compared with synthetic materials, which decay without developing in any way. Our contention in this matter is that this "material narrative" informs, in our view, the Ontological Ballast by registering in a tangible manner a narrative of self through time [6].

Finally, the integration of LCA data supports the concept of "Sustainable Enclothed Cognition" [15]. This finding implies that the harmony between the physical grounding of the material and the user's ethical values is essential [16]. It eliminates the cognitive dissonance that may arise from donning a "grounding" material known to be ecologically destructive. Thus, we conclude that true psychological stability cannot be assumed when the environmental provenance of the garment is unstable.

5. CONCLUSIONS

This study confirms a direct relationship between textile mechanical properties and human neurophysiological responses. The role of texture in this respect has proved to be a powerful neural control factor, with dedicated attentional resource allocation by the brain being a function of fabric thickness and roughness. In particular, establishing the 45.4-micrometer threshold level as a gateway to active neural processing provides a vital design guideline in an increasingly distracting environment to foster presence.

The benefit of using Kansei Engineering will enable a direct conversion of emotional qualitative descriptions into a mechanical parameter to deliberately design a state of mind, such as authority, alertness, and control over emotions, among others.

Additionally, enclothed cognition validity confirms the strength and viability of these findings and implications, underscoring an understanding that people wear and live within clothes, as opposed to wearing them. The rigidity supplied by a custom-made suit or the texture offered by denim meets neurobiological functions regarding the establishment of self-boundaries and alerting.

Nevertheless, there are some inconsistencies that interventions on these concepts should address. The notion of Sustainable Enclothed Cognition specifies that mental stability requires an intact environment.

The utilization of corrected LCA data supports the preference for natural fibers, not only for their inherent tactile complexity, but also for their alignment with a sustainable future.

Most importantly, these findings enable a paradigm shift in design philosophy from aesthetic design towards “prescriptive psychophysics”. Through these findings that prove a particular set of mechanical stimulation, such as shear stiffness and surface roughness, will cause a predictable state of neurophysiology, designers can function as cognitive architects rather than simple aesthetes.

The applications are not limited to consumer-related fashion design studies alone. They include medical interface design studies, where the mechanics of textile could be defined to eliminate sensorimotor processing disorders or cognitive fatigue in the field of high performance. The industry will shift from the visual concept of obsolescence to the concept of cognitive support, whereby the usefulness of the garment will lie in its ability to maintain the cognitive concentration of the wearer.

Ultimately, in a digital age characterized by the dissolution of the self, it is the essence of true fabric - that is, its friction, weight, and moral pedigree - that serves as a constitutive anchor in a world of digital flux. The Significant Form of our clothing is thus used to ground our consciousness.

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