Beyond Vision. Drawing and Design as Multisensory Synaptic Processes

Paolo Di Nardo, Alessandro Spennato, Gianpiero Alfarano

Abstract

This paper explores drawing and design as cognitive and perceptual processes grounded in multisensory dynamics. Through an interdisciplinary theoretical-critical approach, the essay proposes the metaphor of the synapse as an interpretative model capable of describing drawing as a relational device that connects perception, the body, matter and the construction of experience. The multisensory paradigm and theories of embodied cognition allow us to reinterpret representation as an active environment of simulation, anticipation and design modulation. The case study dedicated to the ceramic surfaces project, developed as part of an inter-university teaching initiative between Florence and Perugia, highlights the role of two-dimensional drawing in the generation of sensory surfaces, subsequently materialised through 3D printing. The analysis highlights how the transition from the mark to three-dimensional morphology significantly affects the interactions among vision, touch, and light, contributing to the definition of situated perceptual behaviours. Drawing thus emerges as the cognitive infrastructure of contemporary design.

Keywords: multisensory design, synaptic metaphor, embodied cognition, haptic perception, sensory surfaces, 3D printing.

Introduction

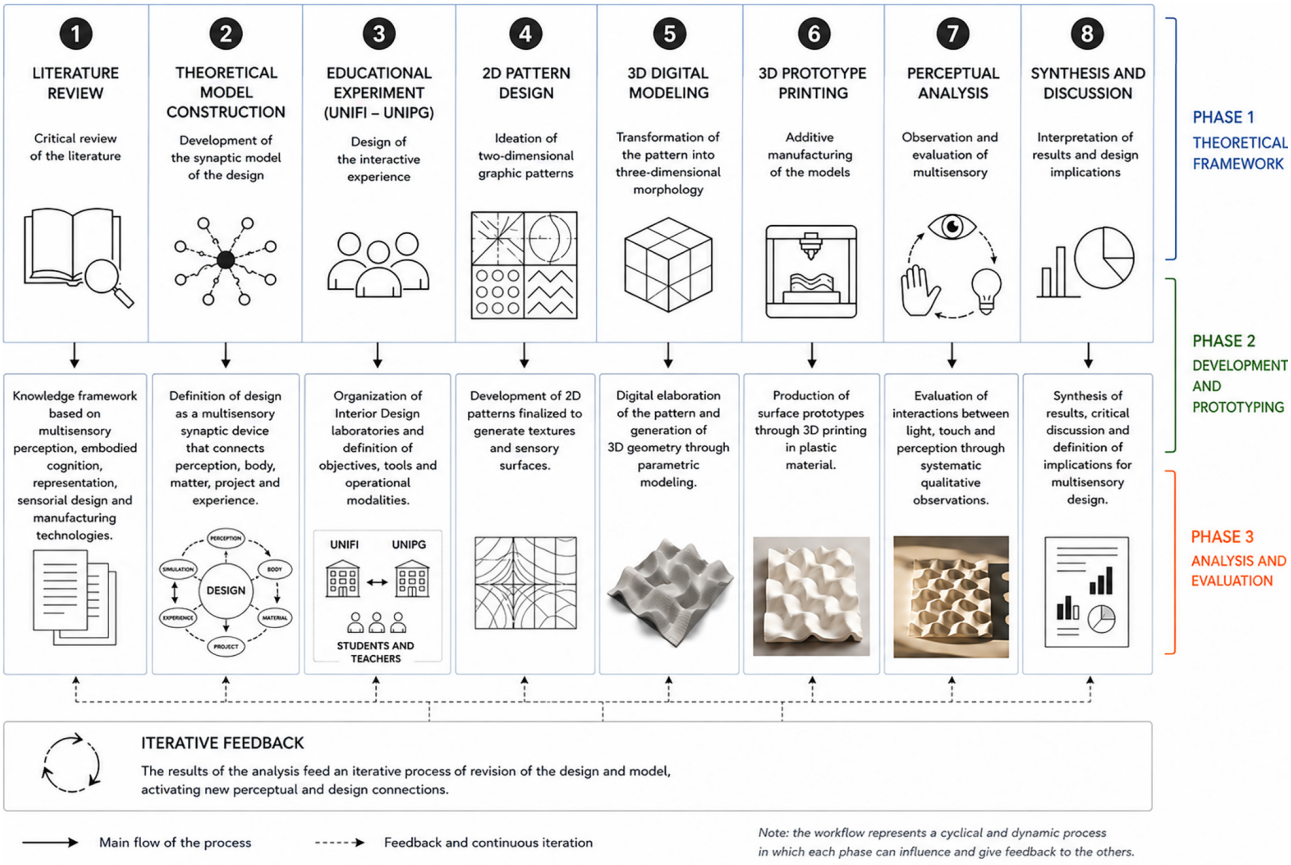
The centrality of vision has historically shaped both drawing practices and design theories, consolidating an eye-centred paradigm that has identified visual representation as the primary vehicle for knowledge, interpretation and transformation of reality. Within this framework, drawing has been predominantly understood as a means of graphically translating the visible, whilst design has often prioritised the formal and iconic dimensions of experience. However, recent developments in cognitive science, phenomenology and sensory studies have progressively challenged this approach, highlighting how perception emerges from integrated, dynamic and multisensory processes, in which the body, action and environment jointly participate in the construction of knowledge [Gibson 1979; Noë 2004].

From this perspective, seeing no longer amounts to receiving images, but to activating sensorimotor relations, perceptual memories and situated interactions. Perception thus takes shape as an embodied phenomenon, in which the subject knows the world through their own being-in-the-world, according to a continuity between sensation, movement and intentionality [Merleau-Ponty 2012]. This theoretical shift implies a substantial redefinition of the role of drawing: no longer a mere practice of description or formal prefiguration, but a cognitive process capable of activating perceptual simulations, experiential anticipations and connections between different sensory dimensions.
Within this framework, this paper proposes to interpret the relationship between drawing and design through the

metaphor of the synapse, taken as an epistemological and operational model. The synapse, understood as a space of relation, transmission and transformation, becomes here a conceptual figure for describing the processes through which drawing connects perception, body, matter and experience. The aim is to investigate how drawing can be understood as a multisensory synaptic process, capable of overcoming the traditional hegemony of the visual and of configuring itself as a cognitive interface between subject and designed environment.

This reinterpretation allows drawing to be situated within an expanded dimension, in which representation, perception and action are no longer separate, but mutually constitutive. In this sense, the essay forms part of the contemporary debate that recognises design as having an experiential and relational nature, and drawing as having a generative, rather than merely descriptive, function [Pallasmaa 2005]. Through a theoretical-critical approach, supported by interdisciplinary references, this contribution aims to outline an interpretative framework in which

Fig. 1. Research methodology workflow: outline of the theoretical, experimental and evaluative phases of the research process, from the development of the theoretical framework to the perceptual evaluation of the prototypes developed (elaboration by the authors).



drawing and design operate as synaptic practices for the construction of knowledge and multisensory experience.
From a methodological perspective, the research adopts a qualitative theoretical-applied approach structured in three integrated phases. The first phase consists of constructing an interdisciplinary theoretical framework through a critical review of the literature on multisensory perception, embodied cognition and sensory design. The second phase involves developing an interpretative model of drawing as a multisensory relational device, employing the synaptic metaphor as an epistemological tool to describe the dynamics of interaction between perception, representation and design. The third phase consists of the applied verification of the model through the analysis of an educational-experimental case study developed in the Interior Design Laboratories of the Universities of Florence and Perugia, aimed at observing the transition from two-dimensional drawing to three-dimensional prototyping of ceramic surfaces in relation to the perceptual behaviours generated (fig. 1).

Drawing and perception beyond the visual paradigm: a synaptic interpretation

The gradual expansion of theories of perception and cognition has redefined the role of vision within experience, situating it within an integrated system of multisensory relationships. Contemporary perception is understood as a dynamic process in which different modalities –visual, tactile, kinesthetic and proprioceptive– cooperate in the construction of meaning. In this context, drawing assumes a function that goes beyond the traditional representational dimension, emerging as a cognitive practice capable of activating perceptual simulations and experiential anticipations. Recent research shows how perception operates through predictive mechanisms, in which the brain integrates sensory stimuli and internal models [Clark 2016]. Drawing thus becomes an act that structures and modulates these dynamics, constructing configurations that guide future experience. The graphic mark is not limited to describing forms, but participates in the construction of perceptual scenarios in which gesture, memory and imagination operate jointly.
Within this perspective, the metaphor of the synapse offers an effective interpretative model for understanding drawing as a space of relation, transmission and transformation. In the field of neurobiology, the synapse represents the dynamic site where signals and connections produce modulations and learning. Transposed into the field of design, it allows us to interpret drawing as a cognitive interface in which perception, the body and design anticipation enter into an active relationship.
From the mark to the construction of experience, drawing emerges as a process capable of activating complex perceptual fields. Lines, densities and rhythmic articulations evoke tactile qualities, luminous dynamics and perceptions of movement. The sheet of paper or digital space becomes an environment for cognitive interaction in which the design unfolds as a circuit of connections and modulations. The mark operates as a synaptic event that coordinates the sensory dimension and formal configuration.
Research on multisensory perception reinforces this interpretation, highlighting how cross-modal integrations directly influence the perception of form and matter [Spence 2020]. Drawing participates in these dynamics by constructing structures of perceptual prediction, through which the designer explores possibilities, verifies consistencies and articulates relationships between evoked experience and emerging form.
Interpreted in synaptic terms, drawing thus assumes a relational function that connects heterogeneous domains: perception and concept, gesture and space, material and imagination. This approach allows us to understand design as a dynamic process of constructing experience, in which representation and perception are mutually constitutive.

Multisensory perception and embodied cognition

The contemporary understanding of perception as a multisensory and embodied phenomenon profoundly redefines the relationship between the body, the environment and design. Cognitive neuroscience shows how sensory systems operate through continuous integration, in which sight, touch, hearing and proprioception work together to construct experience (fig. 2).
Perception emerges from processes of dynamic coordination that link diverse stimuli, expectations and situated action [Stein 2012]. Within this framework, the body serves as an active platform for knowledge.
Embodied cognition describes cognition as a process that develops through the interaction between sensorimotor systems and context. Thinking, perceiving, and acting are intertwined dimensions in which meaning takes shape in the dialogue between organism and environment [Shapiro

Fig. 2. Multisensory experience: Kobe Port Museum/Taisei Design Planners Architects & Engineers (© Katsumasa Tanaka) [Gattupalli 2023].

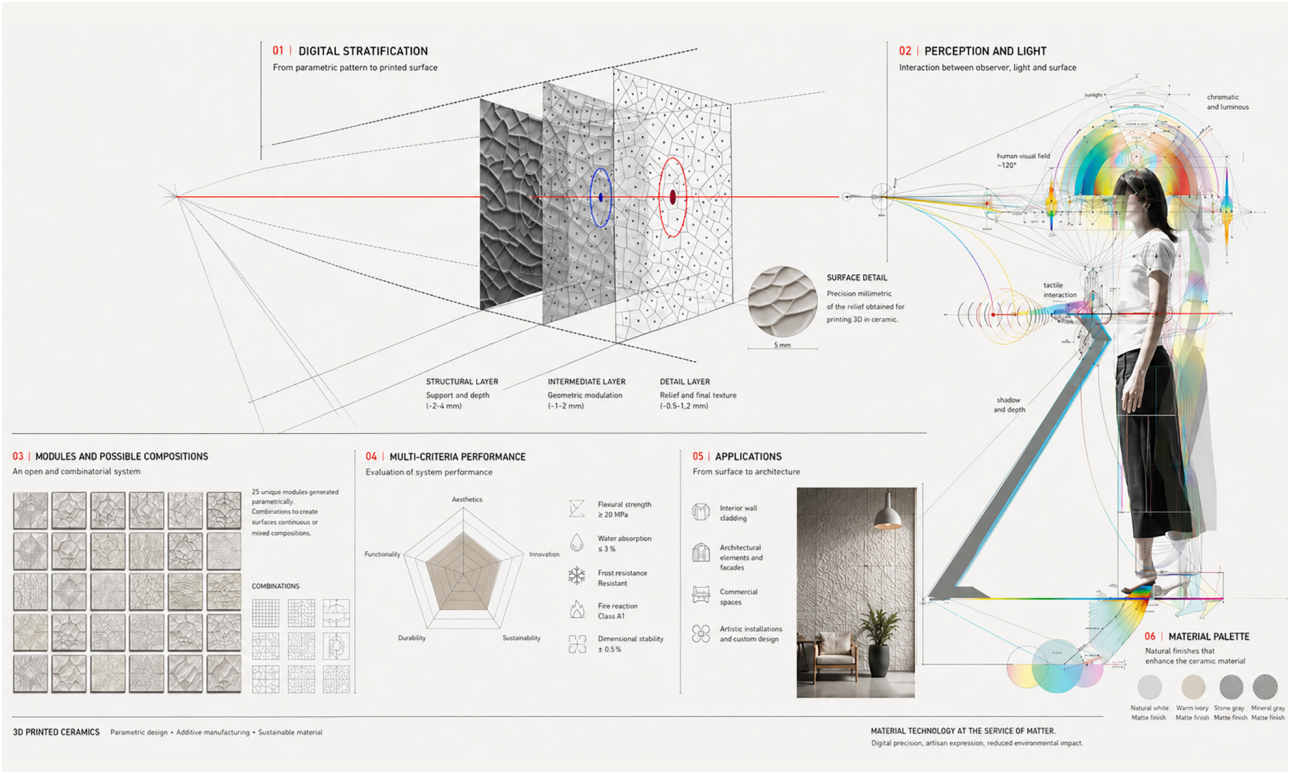
2019]. Viewed from this perspective, the project qualifies as the construction of experiential conditions that engage the body as a whole. Matter, space, light and interaction become variables within a relational perceptual field.
Contemporary experience-oriented design values this approach, viewing artefacts as generators of sensory states, affective dynamics and modes of presence. The designed experience unfolds through tactile qualities, light gradients, acoustic resonances and perceptions of balance and movement [Hassenzahl 2018]. In this scenario, design serves as a tool for anticipating and modulating multisensory configurations, translating perceptual relationships into design structures.
Research on haptic perception and sensorimotor cognition highlights how touch and movement contribute decisively to spatial understanding [Gallace, Spence 2014]. Hand, gesture, and posture influence the formation of mental images and the evaluation of design. Drawing, therefore, involves an activity that integrates perception and action, in which the body explores, verifies and stabilises hypotheses. In this sense, drawing can be interpreted as a practice capable of structuring perceptual configurations and formal relationships that emerge from sensory experience, contributing to the construction of meaning through the dynamics of interaction between form and perception [Alfarano 2015].
The multisensory dimension also introduces a temporal perspective. The experience unfolds as a sequence of perceptual events in which the subject experiences variations in light, texture, temperature and sound. Consequently, the project takes the form of an orchestration of sensory dynamics over time. Drawing allows these modulations to be explored, functioning as an environment for experiential prefiguration and a tool for coordinating perception and intention.
This approach opens up the possibility of reinterpreting drawing as a practice that integrates cognitive, sensory, and motor processes. The graphic construction activates bodily memories, evokes tactile qualities and simulates spatial interactions. Through the mark, the designer articulates scenarios in which the body becomes an implicit parameter of the design. Drawing thus serves as a device that connects sensory experience and design configuration.
The convergence of multisensory perception and embodied cognition thus offers a theoretical framework that can place drawing at the centre of complex relational processes. The project emerges as an embodied experience, whilst drawing functions as a cognitive and sensory infrastructure that renders the relationships between body, perception and environment visible, tangible and adaptable.

Drawing as a multisensory process

Interpreting drawing as a multisensory process means recognising its ability to engage multiple modes of perception simultaneously. Drawing functions as a cognitive space in which visual, tactile and kinesthetic qualities intertwine to construct experiential scenarios. Lines, fields of colour, density, and rhythmic modulations do not act exclusively on the visual plane, but evoke material textures, gradients of light, perceptions of weight, and the dynamics of movement. From this perspective, drawing becomes an environment of sensory simulation, capable of anticipating relationships between body, matter and space (fig. 3).
Recent research on multisensory perception highlights how perception arises from cross-modal integration that directly influences the assessment of form, surfaces and spatiality [Spence 2020]. Graphic representation plays a part in these dynamics by triggering processes of anticipation and perceptual imagination. Drawing is equivalent to constructing configurations that shape future experience, setting the stage for interaction and sensory response. The mark thus takes on a performative function: it does not merely describe, but foreshadows perceptual behaviours.
At the same time, studies on sensory-enabled design show how materials and surfaces are understood through integrated relationships between sight and touch. Drawing occupies this dimension as a device that translates sensory qualities into visual-spatial structures, allowing us to explore the continuity between perception and design. Through variations in scale, rhythm and graphic articulation, the designer constructs perceptual maps that organise sensory experience.
The multisensory nature of drawing emerges with particular clarity in the representation of matter. Textures, patterns, and tonal gradients can suggest temperature, roughness, elasticity, and reflectance. These qualities do not merely evoke physical properties; they also contribute to the construction of perceptual atmospheres. Drawn surfaces become anticipations of experiential states in which light and tactility collaborate to define perceived space. In this sense, drawing functions as a synaptic interface between the sensory dimension and the design configuration.

Contemporary theories of sensory design increasingly emphasise this anticipatory function. Experience-oriented design regards the project as an orchestration of integrated stimuli, in which perception, emotion and cognition operate jointly [Velasco, Obrist 2021]. Drawing contributes to this orchestration by constructing structures of perceptual anticipation that enable the assessment of coherence, intensity and relationships between sensory components. It is not a matter of representing an isolated object, but of simulating a field of experience.
In this sense, drawing takes on an expanded dimension that involves the body, gesture and sensory imagination. The act of drawing integrates haptic memory, visual anticipation and motor simulation, taking the form of embodied knowledge. The design unfolds through continuous exchanges between perception and representation, between evoked experience and formal structure. This dynamic is particularly evident in design approaches that adopt multisensory perception as the structuring principle of spatial and luminous experience [Alfarano 2023].
Drawing, as a multisensory process, thus emerges as a tool for constructing experience, capable of coordinating sensory qualities, design intentions and perceptual behaviours. Through the mark, the designer articulates relationships between the visible and the tangible, between anticipation and presence, defining scenarios in which perception becomes the very substance of the design.

Fig. 3. Perceptual-visual process of light on surfaces (elaboration by the authors).



Case study: surface design and drawing

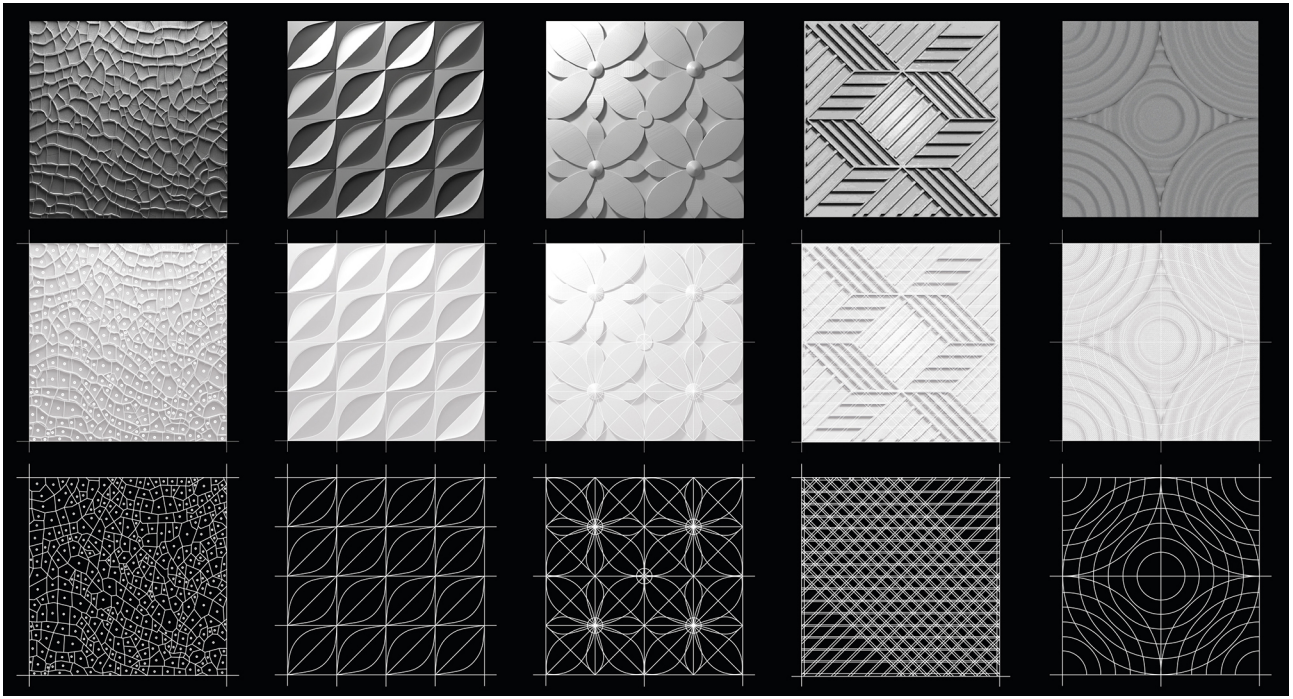
Surfaces as a multisensory device for perceptual mediation

The design of ceramic surfaces provides an ideal context for observing drawing as a synaptic process, understood as a space of connection between perception, material and the construction of experience. The surface is not merely a technical-functional element, but a sensory interface capable of mediating relationships between the body, the environment and the dynamics of light. From this perspective, drawing functions as a cognitive infrastructure through which integrated perceptual qualities are anticipated, simulated and verified (fig. 4).

The synaptic dimension of the process is evident in the design's ability to activate connections between diverse domains: geometric configurations, surface textures, light reflections and tactile expectations. Recent studies demonstrate that the perception of surfaces is guided by predictive multisensory integrations, in which vision constantly interacts with haptic memory and bodily simulations. The tile design thus becomes a field of perceptual experimentation in which the graphic mark translates design intentions into experiential potentials.

This approach finds concrete application in a joint controlled experimental verification developed within the design degree programmes at the University of Florence and the University of Perugia. Students from the Interior Design Laboratory in Florence (around 150) and the Interior Design Laboratory in Perugia (around 200) explored the role of two-dimensional drawing as a generative matrix for sensory surfaces, subsequently materialised through 3D printing technologies (fig. 5). The transition from 2D to 3D has made it clear that design does not merely describe form, but also creates conditions for interaction among light, tactility, and dynamic perception.

Fig. 4. Drawings and diagrams of the graphic design development (elaboration by the authors).

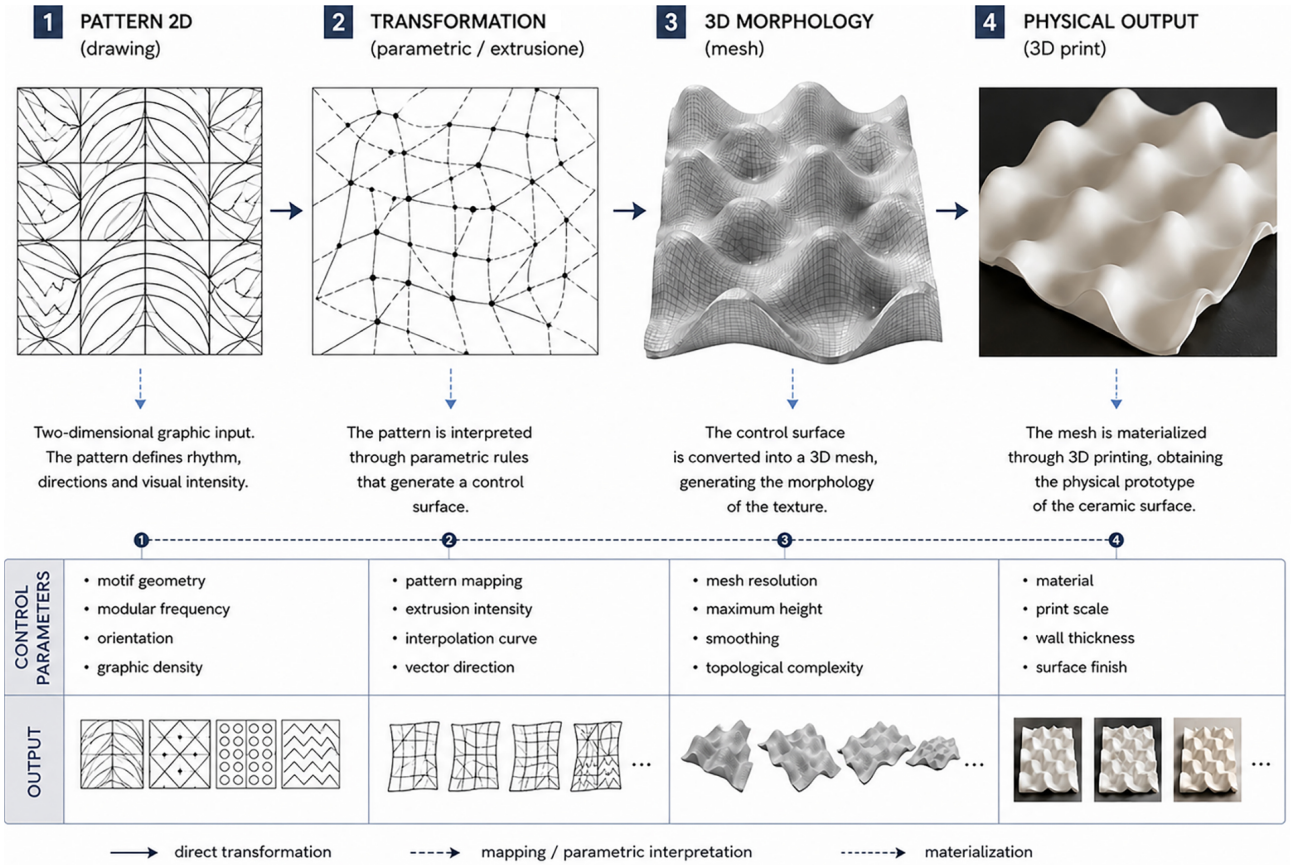


The case study was examined through a qualitative comparative analysis of the prototypes developed, taking into account the different morphological configurations generated from two-dimensional graphic patterns (fig. 6). In particular, the evaluation focused on four main parameters: (a) surface light response in relation to variations in light incidence; (b) perceptual legibility of textures under static and dynamic conditions; (c) haptic perception of surface morphologies; (d) variation in the perceptual effect depending on the observer's movement relative to the surface. This observation enabled verification of the role of design in shaping complex sensory behaviours.

The interplay between sight, touch and light

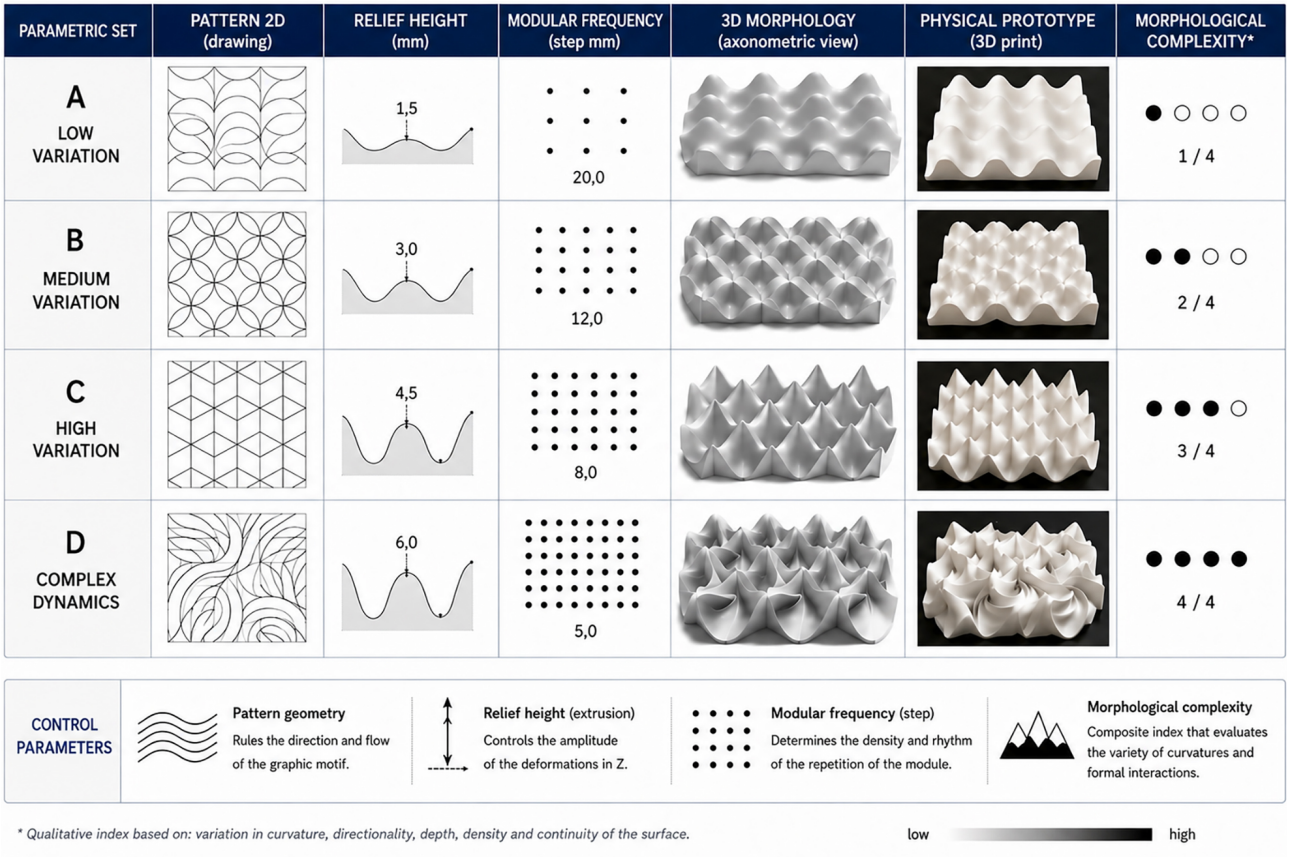
The interaction between sight, touch and light is one of the central themes in the design of contemporary ceramic surfaces. The latest research in the neuroscience of perception shows that the assessment of texture arises from cross-modal integration, in which visual information directly influences tactile expectations and bodily responses [Chen

Fig. 5. From two-dimensional pattern to three-dimensional morphology: transformative workflow of the design process from graphic configuration to physical prototyping of the surface via parametric modelling and 3D printing (elaboration by the authors).



et al. 2021]. The ceramic surface, thanks to its ability to articulate reliefs, microstructures and reflectance gradients, becomes a device capable of simultaneously modulating multiple sensory registers.
Light plays a decisive role in this process. Variations in incidence, diffusion and reflection transform the perception of surface geometry, generating dynamic effects that depend on the observer's movement and environmental conditions [Lee, Kim 2020] (figs. 7, 8). In this context, the design anticipates luminous and perceptual behaviours, functioning as a tool for experiential simulation. Within the Florence-Perugia workshop context, these dynamics were explored through exercises that combined graphic design, digital modelling and additive prototyping. The designed surfaces demonstrated how micro-variations in morphology can produce significant differences in light response and haptic perception. The experience demonstrated how surface design unfolds as an iterative process of synaptic adjustment between gesture, form and perceptual feedback.

Fig. 6. Comparative matrix of morphological variations generated through the parametric modulation of two-dimensional patterns: relationship between graphic configuration, geometric parameters and the complexity of the resulting three-dimensional morphology (elaboration by the authors).



Drawing, matter and perceptual behaviour

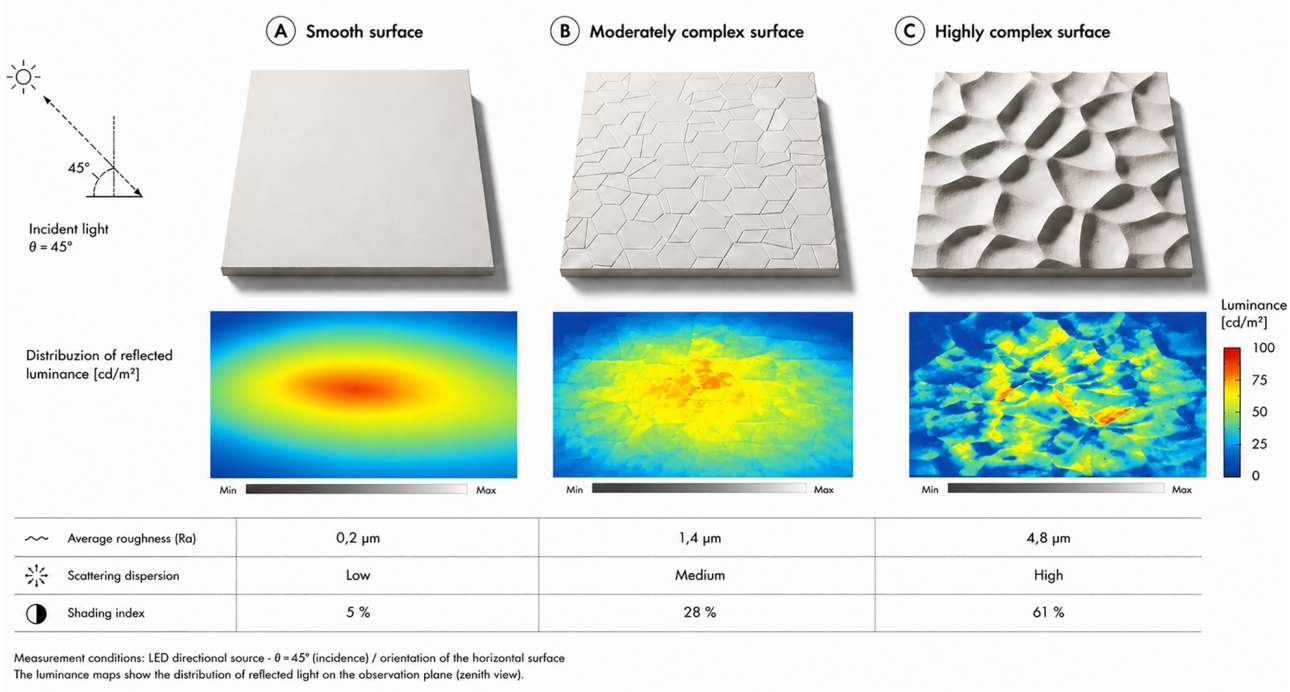
The relationship between design, material and perceptual behaviour is central to the definition of sensory surfaces. Design does not function solely as a tool for formal representation, but as a mechanism capable of structuring modes of interaction and experiential responses. Ceramic material, through its reflective properties, porosity and tactility, contributes to the creation of scenarios in which perception emerges as a relational phenomenon.

At the same time, the digital transformation of production processes in the ceramics sector introduces new possibilities for controlling, simulating and optimising sensory and environmental performance. The integration of Industry 4.0 technologies enables the correlation of design parameters, surface qualities, and sustainability indicators, facilitating a systemic interpretation of surface design [Contini et al. 2023].

Contemporary theories of material engagement highlight how material qualities directly influence cognitive and emotional processes [Malafouris 2021]. From this perspective, design becomes a practice that connects design intention and perceptual behaviour, translating sensory qualities into operational structures. The surfaces generated via 3D printing in the inter-university laboratory have made this dynamic visible, demonstrating how the transition from representation to materialisation produces a qualitative transformation of experience.

Theoretical reflection on the design of sensitive surfaces is further explored in recent research described in the volume Sensibility Surface Design, which interprets the surface as a field of cognitive and sensory activation [Alfarano 2025]. In parallel, studies on the role of multisensory design in surface design highlight how morphological configurations and luminous qualities contribute to the construction

Fig. 7. Comparison of the luminous response based on the morphological complexity of the ceramic surface (elaboration by the authors).



of situated perceptual behaviours [Spennato 2025]. The case study thus demonstrates how design functions as a relational device capable of coordinating perception, matter and light. The tile emerges as a sensory device through which the design becomes an experience, whilst design itself takes the form of a cognitive infrastructure for the relationship between body and environment.

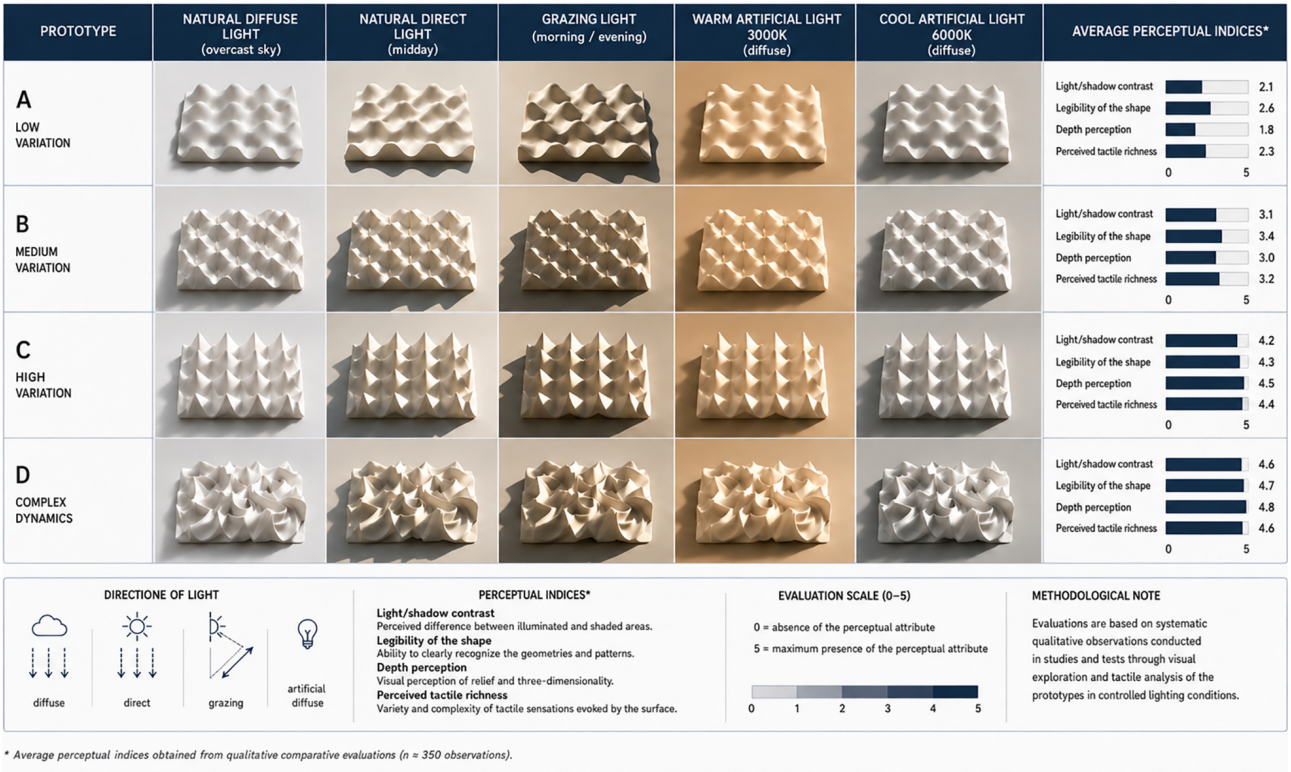
Discussion

Interpreting drawing as a multisensory synaptic process allows us to view representation as a relational practice capable of connecting perception, body and matter. The metaphor of the synapse effectively describes the dynamic nature of drawing: a mechanism that coordinates sensory simulations, experiential anticipations and formal configurations. From this perspective, drawing emerges as the cognitive infrastructure of the project.

Contemporary research on perception highlights the integrated and predictive nature of sensory experience [Clark 2016]. Drawing participates in these dynamics by activating processes of exploration and modulation through which the designer constructs scenarios of interaction. The graphic mark operates as a simulation environment in which form and experience are continuously correlated.

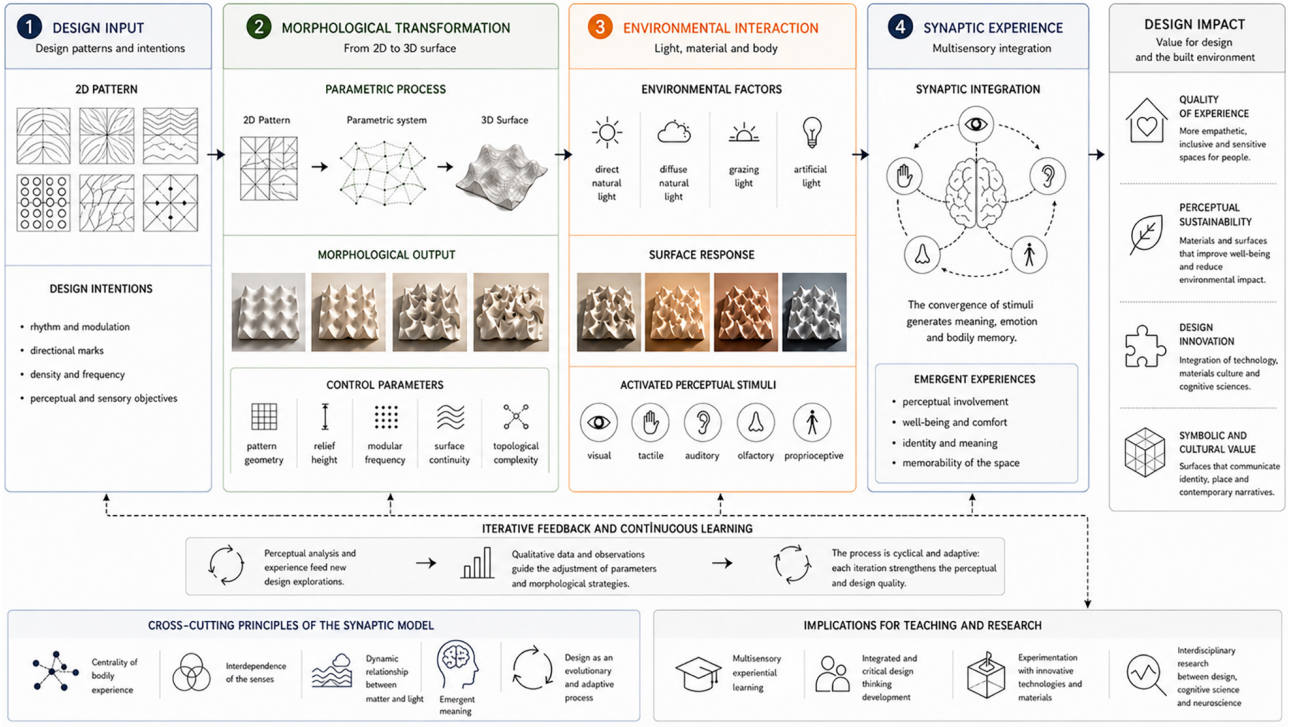
The case study on ceramic surfaces concretely demonstrates this condition. The relationship between graphic

Fig. 8. Comparative analysis of the interaction between light and surface morphology: variation in the perceptual response of the prototypes depending on different lighting conditions and the geometric complexity of the textures (elaboration by the authors).



configuration, three-dimensional morphology and luminous behaviour highlights drawing's capacity to orchestrate complex perceptual qualities. Recent studies confirm how micro-variations in surface texture influence spatial and sensory perception [Kwon et al. 2022], reinforcing the role of drawing as a tool for regulating experience.
This approach suggests a disciplinary redefinition of drawing, emerging as a practice capable of integrating contributions from perception theory, cognitive science, and material design. The project unfolds as an iterative process in which representation, simulation and perceptual verification are closely interlinked.
The methodological and pedagogical implications appear significant. The Florence-Perugia teaching experience highlights how the transition from 2D drawing to 3D printing fosters a broader understanding of the relationship between gesture, material and perceptual behaviour. Additive technologies amplify the synaptic dimension of the process, enabling a direct translation between graphic configurations and experiential prototypes.
Overall, the synaptic model helps to recognise drawing as a practice capable of coordinating sensory, cognitive and design dimensions, thereby consolidating its centrality in contemporary design (fig. 9).
It should be noted that the proposed validation is qualitative and exploratory, based on comparative observation and design verification of the developed prototypes. The contribution, therefore, does not aim to formulate

Fig. 9. Synaptic model of multisensory design: summary diagram of the relationships between graphic configuration, morphological transformation, environmental interaction and the construction of perceptual experience in the multisensory design process (elaboration by the authors).



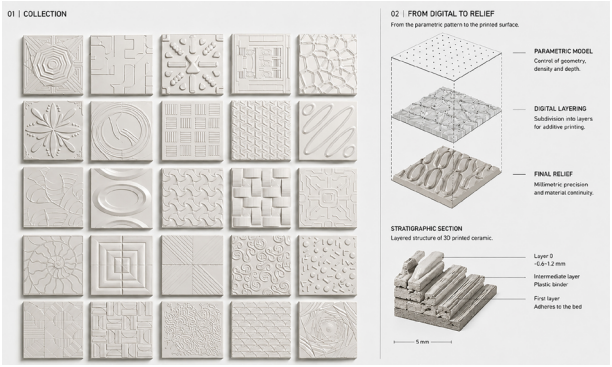
a quantitative measurement of perceptual responses, but rather to outline an interpretative and operational framework useful for understanding the relationships between graphic configuration, three-dimensional materialisation and sensory behaviour.

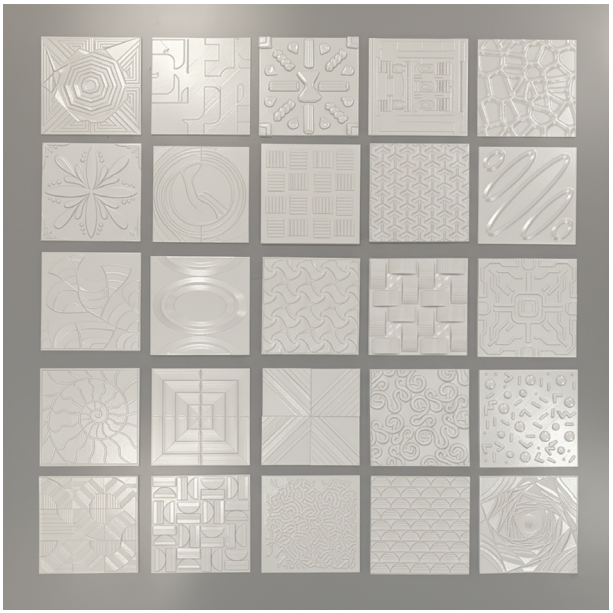
Conclusions

The paper proposed a reinterpretation of drawing and design through the paradigm of multisensory perception and the synaptic model. From this perspective, drawing emerges as an embodied cognitive practice capable of connecting perception, the body, matter and the construction of experience. Representation takes the form of a relational process that triggers sensory simulations and guides design dynamics.
The metaphor of the synapse has enabled the description of drawing as a space of activation and modulation. The mark becomes an interface through which different sensory and cognitive registers enter into a dynamic relationship, contributing to the construction of perceptual scenarios. Drawing thus assumes a generative function, participating in the definition of the project's experiential conditions (fig. 10).
The case study on surfaces provided a practical test of this theoretical framework. The integration of 2D design and 3D printing demonstrated the continuity between graphic configuration, three-dimensional morphology, and perceptual response (fig. 11). The ceramic surface emerges as a multisensory device that mediates interactions among sight, touch, and light.
The disciplinary and methodological implications are significant. Design functions as the cognitive infrastructure of contemporary projects, capable of integrating sensory, material and behavioural dimensions. Digital and additive technologies amplify this dynamic, facilitating iterative processes of simulation, prototyping and experiential verification.
Among the limitations of the research is the qualitative nature of the experimentation, which does not include standardised empirical protocols for measuring users' perceptual responses. Future developments may integrate quantitative methodologies and neuroscientific assessment tools to systematically verify the correlation between graphic configurations, surface morphologies and multisensory behaviour, thereby broadening the transferability of the proposed model.

Fig. 10. Morphological chart of the 3D-printed modules developed in the research: comparative catalogue of parametric patterns designed to explore geometric variations, relief depth, surface continuity and compositional potential of the modular system (elaboration by the authors).

Fig. 11. Photographs of 3D-printed surfaces (elaboration by the authors).





From a pedagogical perspective, the inter-university collaboration between Florence and Perugia highlights how integrating drawing, modelling, and additive manufacturing fosters a broader understanding of design as a multisensory process. Students directly experience the relationship between gesture, material and perceptual behaviour.

Overall, the proposed perspective helps position drawing beyond mere vision, recognising it as a synaptic practice capable of coordinating perception, materiality, and experience. This approach opens the way for further research aimed at exploring the relationships between representation, neuroscience, and multisensory design.

Authors

Paolo Di Nardo, Department of Civil and Environmental Engineering, Università degli Studi di Perugia, paolo.dinardo@unipg.it
Alessandro Spennato, Department of Architecture, University of Florence, alessandro.spennato@unifi.it
Gianpiero Alfarano, Department of Architecture, University of Florence, gianpiero.alfarano@unifi.it

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