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RELATING CREATIVITY TO AESTHETICS THROUGH LEARNING AND DEVELOPMENT: AN INTERACTIVIST-CONSTRUCTIVIST FRAMEWORK

Ioannis Xenakis & Arnellos Argyris

COMPLEX SYSTEMS AND SERVICE DESIGN LAB,
DEPARTMENT OF PRODUCT AND SYSTEMS DESIGN ENGINEERING,
UNIVERSITY OF THE AEGEAN

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ABSTRACT

One of the most yet unresolved theoretical problems in creative thinking concerns the relation between creativity and aesthetics. Standard models of aesthetics rarely offer a functional naturalistic explanation that integrates these two notions within a single framework. As a result, aesthetics and creativity remain paradoxically intertwined yet conceptually disconnected, developing as research fields with limited cross-theoretical engagement. The paper approaches the problem from a non-art-related perspective, grounded in a fundamentally different metaphysical framework. In explaining how explorations towards novel and appropriate ideas aim at significant changes in knowledge constructions, the relation between aesthetics and creativity must necessarily be grounded in learning and development. However, we argue that standard models of the modular aesthetic mind face critical limitations in incorporating learning and development, thereby, failing to account for genuine knowledge transformation in creative explorations. As an alternative, we propose an Interactivist-Constructivist model of Aesthetics, which overcomes these limitations. Our claim is that a value-rich aesthetic sense of future interaction states is not only functionally integrated with learning and development but also actively shapes ideation paths within creative explorations. This aesthetic sense is both enabled by and facilitates further learning and development. Rather than existing as an isolated aspect of creative thinking, aesthetics are intrinsically embedded in the knowing ontology serving functional role: to reduce uncertainty in creative explorations, thus indicating and opening the door to new creative ideas and opportunities of further interaction.

Keywords: creativity; aesthetics; interactivist-constructivist framework; self-directed learning; development; ideation

1 INTRODUCTION

One of the most persistent yet unresolved theoretical problems in creative thinking concerns the relation between creativity and aesthetics. There is broad agreement on this relation because art inherently requires novelty. Since novelty is a defining feature of art, creativity is often considered an essential component of aesthetics (Yeh et al., 2019). This widely accepted yet common-sense argument originates in Continental[1] philosophical tradition of aesthetics, where artistic creations are assumed to be inherently tied to creative thinking (Zaidel, 2016).

As a result, these special objects are assumed to contain built-in "creative devices[2]" that contribute to their aesthetic value (see Tinio & Leder, 2013).

Following this tradition, experimental and theoretical investigations in this field have rapidly established a standard doctrine in which creativity and aesthetics are viewed as two sides of the same coin: creativity pertains to how artists embed these creative devices in artworks, while aesthetics concern how observers recognize and experience the value of those embedded features (see Tinio & Leder, 2013; Vartanian, 2014). This doctrine underpins a predominantly art-oriented psychological research program that examines the relation between creativity and aesthetics. The underlying assumption is that by appreciating the merit of artworks (see Briskman, 2012; Tinio, 2019), scientists can unravel the creative process itself (see Spee et al., 2023).

This tension marks a key gap that the present paper aims to address. Although creativity and aesthetics are widely believed to be interconnected, this relation has rarely been examined through a unified explanatory lens. As a result, contemporary research lacks a naturalistic explanation that integrates them into a coherent framework. Despite their apparent interconnection, aesthetics and creativity remain conceptually disjointed, evolving as separate research fields with parallel trajectories (Tinio, 2019; Vartanian, 2014). This divide is evident in Martindale's (2007) review, where aesthetic and creative explorations[3] are treated through distinct theoretical frameworks. To our knowledge, the mirror model proposed by Tinio (2013) is the only attempt to explain how creators not only observe but also embed these creative devices in their artwork. However, this model does not account for how creative devices can be used appropriately[4] to drive artistic novelty.

Our aim in this work is to approach this problem from a non-art-oriented perspective. The proposed method for investigating a possible relation between aesthetics and creativity is grounded in the role that learning and development play in creative explorations. It is widely accepted that a creative exploration is based on how a knowing system achieves significant transformations within a domain of knowledge —transformations that are functional for its goals (see Feldman, 1989, 1999; Hui et al., 2019; Simonton, 2000; Weisberg, 1999). Consequently, any explanation that links aesthetics and creativity must also account for how aesthetics contribute to acquiring new knowledge. By clarifying the connection between aesthetics, learning and development we can better understand how aesthetics relate to creativity.

The next step is to examine whether the standard doctrine of aesthetics — shaped by the modular [5] view of the mind (see Fechner, 1876; Fodor, 1983)— can adequately support an explanation of how creative transformations emerge through learning and development. In Section 2, we show that this framework encounters fundamental limitations: by assuming that aesthetic encodings are innate, fixed, and functionally encapsulated, it cannot account for novelty, developmental refinement, or appropriateness in creative exploration.

In Section 3, we shift focus to the role of learning and development in creativity. Drawing on the Interactivist-Constructivist[6] paradigm in cognitive science — alongside related contemporary research in cognition and metacognition — we argue that creative exploration depends on self-directed processes that allow a knowing system to reorganize its interaction trajectories, construct knowledge, and refine its goals under uncertainty. This section explores why and how learning and development are fundamental in directing a knowing system toward creative explorations in order to achieve novel but also appropriate knowledge — what we call a "novel and functional idea." These insights provide the foundation for our Interactivist-Constructivist framework.

Finally, in Section 4, we introduce an alternative Interactivist-Constructivist model of Aesthetics that not only overcomes the above limitations but also —to our knowledge, for the first time—suggests that "interaction aesthetics" result from cognitive and metacognitive regulations within the system. These regulations are enabled by self-directed anticipative learning and developmental functions.

In cases of uncertainty, when the existing knowledge is insufficient in providing novel and functional ideas, learning and development aid/enable the system to anticipatively know its task environment[7]. Learning regulations provide a value-rich aesthetic sense of future interaction states, signaling for indications of potential opportunities or of ineffective or unstable interaction outcomes. Additionally, a meta-level aesthetic sense — that is, a reflective evaluative sense constructed at higher levels of knowing — signals the system about the overall quality of the ongoing exploration. This quality, once reflectively organized, gives rise to the aesthetic experience of being creative in a situation — that is, the experience of having an aesthetic sense (Xenakis, 2018; Xenakis et al., 2012; Xenakis & Arnellos, 2013, 2015, 2017).

Interaction-aesthetics should not be confused with aesthetic properties that work as elements[8] to be "creatively" combined and attached to an object. Unlike the standard doctrine, the emergence of an interaction-aesthetic sense does not presuppose a special ontology in the mind that is activated in response to special stimuli. Thus, aesthetics and creativity are not modeled as two isolated, parallel or sequential faculties with distinct characteristics that take place inside or outside[9] the knowing ontology. Instead, we propose that aesthetics and creativity are functionally integrated within the same knowing ontology, compelling the system to abandon established practices and explore new opportunities for constructing novel and functional ideas.

We believe that this discussion will offer functional insights and new perspectives not only to researchers working on aesthetics and creativity, but also to those who investigating aesthetic learning and development. The latter remains either underexplored, treated as a black box (see Reid, 1982) or dismissed as an impossible task (see e.g., Elkins, 2001; Hagen, 1985).

2 FACULTY PSYCHOLOGY, PSYCHOPHYSICS AND PSYCHOLOGY OF AESTHETICS

Faculty Psychology conceptualizes cognition as a collection of distinct psychological faculties, each dedicated to a specific domain (see Chomsky, 1980; Fodor, 1983; Marr, 2010; Pylyshyn, 1980). These faculties are typically modeled as modular and encapsulated units, endowed with innate domain-specific structures that operate independently — much like biological organs. Although some theorists, such as Marr (2010), have proposed multiple levels of analysis (computational, algorithmic, implementational), these levels are treated as analytically distinct and not as dynamically integrated through developmental processes. The overall modular framework constrains cognition to a fixed architecture: learning cannot reorganize or transform these modules, and no mechanism exists for the emergence of novel functions across levels. As a result, developmental change — especially in the form of integrated learning across representational levels — is largely excluded from this cognitive model.

This framework became especially influential in shaping psychological approaches to aesthetics. Both Fechner's psychophysics and Fodor's theory of the modular mind helped establish the core assumptions of modularity that continue to shape the field. Fechner (1876) introduced the foundational idea that aesthetic experience could be reduced to fixed sensory correspondences, setting the methodological agenda for the Psychology of Aesthetics. Later, Fodor's (1983) account of modular cognition, with its emphasis on innate, domain-specific processing, reinforced these assumptions.

In Section 2.1, we explain how this cognitive architecture models perception as a transduction process that internalizes sensory content through domain-specific faculties. In Section 2.2, we examine how contemporary models in aesthetics build on this structure, treating aesthetic experience as the product of fixed, encapsulated systems — a view that fundamentally limits the role of learning, development, and creativity.

2.1 INTERNALIZING THE WORLD INTO THE MODULAR MIND

In much the same way that Fodor (1983) explains the modular mind, Fechner (1876) defined psychophysics as the doctrine of correspondences between physical and psychological entities (Heidelberger, 2018). Both Fodor and Fechner propose a dual-structure architecture of cognitive processing, consisting of two functionally isolated layers that differ in their epistemic status. Each layer of processing describes a transformation mechanism responsible for internalizing energy stimuli from the external world into corresponding faculties of the mind. This internalization process is widely known from Fodor's work, as "Transduction"[10] or "Induction".

The first layer of common transformations, often referred to as "outer psychophysics" is based on fixed correspondences or "encodings"[11] that associate domain-specific aspects of the world with domain-specific modules in the mind. It is useful to conceptualize this layer as a set of pre-specified neural architectures that are fast, autonomous, mandatory, automatic, and stimulus driven, responsible for generating the objective image of the world (Karmiloff-Smith, 1994).

In modular theories of mind, encodings are by definition considered "innate"[12] meaning they are pre-specified mappings that associate specific environmental inputs with dedicated cognitive modules. These innate structures are responsible for forming fixed sensorial conceptualizations[13] of the external world (see Fodor & Pylyshyn, 2015; Pylyshyn, 1980). According to Fodor (1983, 1985) all human ideas are combinatorially assembled within a single-level of processing by innate, domain-specific encodings. Consequently, neither encodings nor their combinations can emerge or be constructed from lower-order cognitive processes. Encodings are always present within the modular encoding layer, merely awaiting activation when the appropriate stimulus enters the sensory system.

Their activation is characterized by "cognitive impenetrability" —encodings cannot be influenced by top-down cognition, meaning their content cannot be altered through learning. It is evident that modularity stands in direct opposition to Piaget's (1956) constructivism as well as modern approaches such as the Interactivist-Constructivist framework (see Bickhard, 1991) and the Psychological-Constructionist account (see Barrett, 2009).

The second layer of processing concerns personal transformations and is often referred to as "inner psychophysics". Its objective is to internalize outputs from of the modular encoding layer into the central processing system. This layer operates autonomously and is not contingent on external stimulation. Instead, it integrates current sensory inputs with learning processes, enabling individuals to appreciate and interpret what has just been observed. The central processing system involves faculties like emotions, goal-setting, and learning functions, which ultimately combine district encoded conceptualizations into a meaningful event. These meanings are private, forming the basis of subjective experiences and personal ideas about the world (Moye & Moye, 2021).

In general, the modular theory of mind has been widely criticized as a mechanistic or computational paradigm of cognition, in which each faculty or module is viewed as being dedicated solely to carrying out a fixed set of specialized tasks, presumably passed on via evolution. The proposed dichotomy between these two distinct layers of processing — and the resulting inability to integrate perception, emotions, learning, motivation, and action-selection, into a unified cognitive ontology — poses serious theoretical problems (see e.g., Bickhard, 1991; Godfrey-Smith, 2003; Karmiloff-Smith, 1994; Militello & Moreno, 2018).

Key works in neuroscience further argue that modularity-inspired studies are misguided, as the assumption of modularity in sensory cortices remains highly questionable (see e.g., Barrett, 2009; Barrett & Satpute, 2013; Hackel et al., 2016; Pessoa, 2008; Spunt & Adolphs, 2017; Uttal, 2001). Additionally, the modular theory has been extensively criticized for its inability to explain the emergence of genuine representational or perceptual contents and its failure to account for representational and perceptual error. Furthermore, it stands in sharp contrast with domain-general theories of learning and development (see e.g., Bickhard, 1998, 1999, 2009c; Bickhard & Richie, 1983).

In the following section, we will focus mostly on correspondence-based explanations related to aesthetics, emphasizing their implications for understanding learning, development and creative thinking in this domain of research.

2.2 THE AESTHETIC MODULAR MIND, IMPLICATIONS IN LEARNING, DEVELOPMENT, AND CREATIVITY

In many contemporary models of aesthetics within the field of Empirical Aesthetics (see e.g., Chatterjee & Vartanian, 2014; Jacobsen, 2006; Leder et al., 2004; Tinio, 2013), one can see a strong influence of the modular theory of mind. These models typically adopt a linear structure of aesthetic observation and apperception, beginning with visual input systems, which are sensitive mostly to artistic stimuli.

A fundamental assumption underlying these models is that the perception of artistic objects is determined by the detection of combinations of physical aspects, commonly referred to as 'aesthetic properties.' In aesthetic literature, aesthetic properties are generally understood as the elements that transform an everyday object into an aesthetic one (for a detailed discussion see Xenakis & Arnellos, 2022).

In sort, transducers internalize visual inputs of aesthetic properties, directly processing them through domain-specific modules that activate innate primitive aesthetic conceptualizations such as symmetry, contour, visual balance, elegance, contrast, prettiness, harmony, shapeliness, or charm. From this point, we will refer to these innate correspondences "aesthetic encodings".

The processed outcome is then further internalized into a "central processor", which executes several subjective appreciations about the observed artwork. Using the faculty of learning, the internalized sensory aesthetic encodings are appreciated in terms of their prototypicality, and familiarity or are categorized according to established artistic or historic conventions, such as Impressionism, Cubism, etc. Jacobsen (2006) has proposed seven perspectives for appreciating such inputs: diachronia, ipsichronia, mind, body, content, person and situation. Finally, this refined information is further combined to form meanings related to what the artwork depicts. During this phase, the distinct faculty of "aesthetic emotions" is engaged to assign an aesthetic value to this observation (see Menninghaus et al., 2019).

It is important to note here that the above models do not offer explanations on how these innate aesthetic encodings appear in the mind, how the mind learns and how it develops its ability, not only to make more effective aesthetic appreciations but, more importantly, to create novel or genuine aesthetic encodings. These models conceptualize aesthetic appreciation as a passive capacity, in which the knowing system merely responds to works of art.

The only exception is Tinio's (2013) "mirror model", which attempts to explain how the creator is not only an observer but also an active producer of "aesthetic" images. However, this model does not explain how combinations of aesthetic encodings enable artists to create novel and appropriate works of art.

As we will further explain in the following sections, correspondence-based models struggle to account for novelty, while functionality or appropriateness remains a fringe topic in aesthetics. For reasons that we analyze next, models that adhere to modularity face significant limitations in supporting learning and development, making the link between aesthetics and creativity untenable.

2.2.1 THE AESTHETIC MODULAR MIND CANNOT ACCOUNT FOR GENUINE AESTHETIC CONCEPTS: IMPLICATIONS ON NOVELTY

One of the major theoretical challenges facing the aesthetic modular mind is the problem of "innatism". The argument is that when aesthetic problem are encountered, innate aesthetic encodings must be activated in the mind and directly applied to what it is observed (see Jacobsen & Beudt, 2017). Since aesthetic encodings are innate, they cannot emerge or be constructed by any known model of learning. As a result, the appearance of novel aesthetic encodings in the mind is theoretically impossible.

This leads to a critical limitation: not only is it impossible to recognize aesthetic encodings other than those already existing in the mind, but the aesthetic modular mind is incapable of creatively directing the knowing system to generate new encodings. If neither construction nor evolution could ever get a novel aesthetic encoding to emerge (Bickhard, 2009c; Karmiloff-Smith, 2015), the entire aesthetic modular mind faces a fundamental problem —how do aesthetic conceptions, properties, particles, features, etc., (which are in fact the core concept of aesthetic theory) come into existence in the first place?

The most practically limiting implication of innatism within the aesthetic modular mind is that the knowing system seems unable to engage in genuine creative explorations and to learn ways to form novel aesthetic conceptualizations. Instead, the aesthetic modular mind remains genetically and epistemically confined to passively interpreting the observed world through a fixed pool of pre-given aesthetic encodings or aesthetic particles, all processed in a single-level framework (see Bickhard & Terveen, 1995; Xenakis & Arnellos, 2017).

Martindale (1999) is explicit on this point: novelty in aesthetics involves the realization of an analogy between previously uncombined aesthetic encodings. Consequently, in the aesthetic modular mind, creative exploration is reduced to a search for uncombined aesthetic encodings across the history of art. Since aesthetic encodings, by definition, cannot be in error—they either exist or not exist in both the mind and the world—learning within this framework is limited to corrections of this combinatoric process.

This remains an unresolved paradox: there is no epistemological, philosophical, or cognitive basis for determining under what conditions a new combination of previously uncombined aesthetic encodings can be considered both novel and appropriate. This remains an open and unresolved problem in aesthetic theory.

2.2.2 THE AESTHETIC MODULAR MIND CANNOT ACCOUNT FOR GENUINE AESTHETIC CONCEPTS: IMPLICATIONS ON APPROPRIATENESS

The problem of appropriateness becomes theoretically unsolvable when the aesthetic modular mind is further constrained by a transcendental idealistic metaphysical assumption. As outlined in Xenakis and Arnellos (2022) this assumption combines aesthetic realism — which treats aesthetic properties as mind-independent, inherently normative, and only partially accessible to conceptual understanding — with elements of Kant's transcendental idealism. Based on the classical Kantian notion of "disinterestedness" [14], aesthetic realism assumes that the activation of aesthetic encodings should not be self-directed. Unlike everyday encodings that serve a functional purpose (e.g., code languages like Morse Code), aesthetic encodings are presumed to be independent of the knowing system's goals.

This assumption remains central in contemporary explanations of aesthetics in art and design (see e.g., the frameworks of Hekkert & Leder, 2007, p. 262; Lawson, 2005, p. 12). According to this assumption, creative explorations and aesthetic emotions they involve are regarded as a special kind of non-self-directed contribution (see e.g., Makin, 2017; Marković, 2012). Since there is no goal to accomplish, the process lacks any internal criteria for progress. As a result, the knowing system cannot evaluate or regulate its own aesthetic exploration, because there is no learning involved and no possibility of feedback or correction. Because aesthetic encodings are assumed to be inherently correct, there is no room for error — and therefore no basis for correction or development. Within the modular aesthetic mind, creativity is externally imposed on this passive knowing system and is not associated with significant changes in the existing body of knowledge.

Moreover, since the modular aesthetic mind operates at a single level of knowing, it cannot generate metacognitive experiences regarding the long-term consequences of a creative exploration. Reflections like "Am I a creative person?" cannot be answered in a way that allows someone to improve their own creative performance. Instead, short-term learning loops that assess the appropriateness of creative exploration are considered goal-directed and logical and therefore, non-aesthetic (Stolnitz, 1961).

It is now evident that, within the modular aesthetic mind, aesthetic conceptions as well as their combinations are, by definition, devoid of proper function —neither within the mind nor in the object itself. Because aesthetic encodings are assumed to be inherently correct and cannot fail, they are not open to error or revision. Consequently, they are not normative: there is no way to evaluate them as more or less appropriate, because the framework excludes the very possibility of developmental failure or correction. Beauty is not approached as a goal with conditions of success — things are either beautiful or they are not according to fixed perceptual encodings. While this suggests a kind of implicit normativity, it is not constructed or evaluated by the person itself. There are no developmental criteria, no feedback, and no capacity to refine or revise aesthetic judgments. Because persons cannot distinguish between more or less appropriate configurations, they lack any functional notion of normativity in the constructive sense. These outcomes result from unconstrained recombinations of static elements, without any possibility for internal evaluation, feedback, or goal-directed refinement. When these outcomes are accurate, they *ought to* please the eye (see Jacobsen & Beudt, 2017); and when inaccurate, they are treated as misperceptions.

Consider the simplest encoding case, assuming an innate encoding exists. For instance, the depiction of “* | *” in a wall corresponds to the conceptualization of “visual balance”. The conceptual content is inherently accurate when “* | *” appears in perception, and as result, the knowing system is pleased upon directly recognizing “visual balance”.

Since, in modular theories, encodings are treated as innate, pre-specified, and automatic, they are assumed to activate reliably when the appropriate stimulus is present. As such, they cannot fail[15] in the sense of being revised or misapplied — every knowing system, under proper conditions, *ought to* perceive them accurately.

If, however, “visual balance” does not occur in perception (e.g., the knowing system perceives “* | *” that corresponds to “symmetry”), two possibilities arise:

1. “Visual balance” is absent from the observation, and thus, the knowing system is not pleased,

2. The content of the observation is inaccurate, and the knowing system is misled—either it fails to feel pleasure when it should, or it feels pleasure for a different reason.

The latter case is referred to as misperception. It can be signaled only by an external system (Xenakis & Arnellos, 2017), which observes that an external condition (e.g., an incorrect vantage point) caused “visual balance” to be perceived as “symmetry”. However, this assumption introduces a paradox: we must also assume that the external system has a "perfect" vantage point, ensuring that its perception of "visual balance" is not itself a misperception.

Within the modular aesthetic mind, the knowing system can never have a true access to external reality, since what it observes and feels can be a result of a misperceived world (Xenakis & Arnellos, 2017, 2022). More importantly, a modular aesthetic mind is incapable of learning to correct these inaccuracies. Therefore, learning—particularly anticipative learning—in aesthetics is impossible, and any concept of creativity that relies on learning and developmental changes is inherently inapplicable.

Furthermore, it is tautological to teach a modular aesthetic mind the conditions of success for aesthetic encodings, when such conditions are already established in this mind. The only viable approach is to teach an unlimited number of "cases-to-avoid" —instances where inaccurate depictions should be prevented. Art academies have traditionally taught beauty through such "avoiding loops" (e.g., you shouldn't do "X") without, however, providing a clear description of how things should be (Jacobs, 2009; Mace & Ward, 2002). However, teaching through avoiding loops can only work when the aesthetic encoding is not fixed but relative, requiring more abstract ways to formalize associations.

Yet, if encodings are open to interpretation, they are no longer fixed correspondences but rather subjective constructions. This introduces a notable contradiction within the modular aesthetic mind: while theory assumes fixed, innate encodings, in practice, students subjectively comprehend, interpret, and apply aesthetic encodings in ways that deviate from this rigid framework (Journeaux & Mottram, 2016).

2.2.3 METHODOLOGICAL AND THEORETICAL IMPLICATIONS FOR DEVELOPMENT

Research in aesthetic development follows the linear progressive growth of art comprehension discussed above. One can find several similar models but the most known is that of M. J. Parsons (1976). Within this framework, aesthetic development is understood as a child's ability to progressively activating preexisted aesthetic encodings through observation, reflection, and response to art (Chen, 1997). However, studies on aesthetic development notably exclude the creative process, as Parsons explicitly states:

"such a theory would focus on the child's experience as he responds to works of art, rather than as he creates them…" (M. J. Parsons, 1976, p. 305).

In general, researchers acknowledge that the challenges of studying aesthetic development are both methodological and theoretical. Methodologically, it is difficult to design stimuli that young children can interpret as aesthetically relevant. Experimental designs often assume that participants will detect aesthetic properties as pre-encoded features of aesthetic value, but children frequently do not interpret the task this way. Instead, they respond based on their own situated understanding or contextual associations — for example, seeing a sound as noise rather than music, or viewing a painting as a picture rather than as art. These responses suggest that participants are not decoding fixed aesthetic values from the stimulus but are instead constructing meaning based on prior experience or social cues. This raises the question of whether observed reactions genuinely reflect spontaneous developmental constructions or are products of instruction or imitation (Gardner et al., 1975). Crucially, such findings challenge the assumption — central to modular theories — that aesthetic encodings are innate.

Aesthetic development research often faces a structural mismatch between two incompatible paradigms of cognition. On one hand, constructivist accounts (e.g., Piaget, 1956) view development as self-directed, domain-general, and normative — meaning that knowledge is actively constructed through exploratory learning and reorganized over time. On the other hand, modular aesthetic theories assume that art appreciation is non-self-directed, domain-specific, and descriptive — meaning that aesthetic judgments depend on the automatic internalization of predefined conceptual contents, such as innate standards of beauty (Reid, 1982). These opposing assumptions are difficult to reconcile, as the former supports developmental flexibility, while the latter posits a fixed, encapsulated process. This tension undermines the ability of modular models to explain how aesthetic understanding actually evolves.

Both the methodological and the theoretical limitations described above significantly restrict the applicability of the conclusions drawn from studies on aesthetic development. In many cases, researchers often embed implicit metaphysical assumptions within their hypotheses, — such as the idea that aesthetic properties exist independently of the knowing system and should be immediately recognizable — and these assumptions then shape their interpretations of participants' responses (Taunton, 1982; Xenakis & Arnellos, 2022).

This issue is particularly evident in Parsons' model of aesthetic development which presupposes an ontological dualism between "ordinary" and "aesthetic" encodings. Based on this dualism, Parsons (1976, p. 306) concludes that "a cognitive theory is inappropriate" for modeling aesthetic development. More radical dualists (see e.g., Elkins, 2001; Hagen, 1985) extend this claim by rejecting the very notion of development in the aesthetic domain. They argue that cognitive development necessitates rational justification, whereas "the aesthetic", by its very definition, is assumed to be disinterested and irrational.

2.2.4 ALTERNATIVE MODELS OF AESTHETIC DEVELOPMENT

In an attempt to address some of these challenges, Kindler and Darras (1998) and Wolf and Perry (1988) propose "the pictorial repertoire theory" as a more pragmatist perspective of development, drawing from Piaget's constructivism and Pierce's semiotics. Their model emphasizes the goal-directed construction and development of a "repertoire of pictorial or drawing systems". However, while they intend to model aesthetic development, their focus is primarily on explaining the developmental possesses of drawing activity. They conceptualize drawing as a goal-directed, ill-defined cognitive activity, the development of which is an emergent construction guided by the dynamic goals of the individual (Kindler, 2004).

However, a drawing system is defined *"a set of rules designating how the full-size, three-dimensional, moving, colored world of ongoing visual experience can be translated into a set of marks on a plane surface"* (Wolf & Perry, 1988, p. 19). Such drawing systems are implicitly combinations of object-based symbols, which are constructions that children dynamically form to depict concepts in their drawings.

While this model supports learning and development in a manner similar to how children learn and develop their writing ability when acquiring a language system, it is important to recognize that these drawing systems serve as a medium for depicting ideas, rather than being ideas themselves. An idea cannot be reduced to a drawing, nor do all drawings involve ideas. Furthermore, like any symbolic representation, these drawing systems cannot inherently be aesthetic. The development of drawing or writing skills indeed presupposes cognitive development, unless this drawing development is framed as a process of forming new combinations of aesthetic encodings. In the latter case, the pictorial repertoire theory risks becoming just another correspondence-based model.

In short, if the construction of novel representational or aesthetic content is to be explained, it cannot rely on fixed correspondences or innate encodings. It requires a developmental framework in which learning and self-directed differentiation are central. In the next section, we turn to the role of learning and development in creative explorations, highlighting how these processes enable the emergence of novel and functional ideas.

3 CREATIVE EXPLORATIONS REQUIRE ANTICIPATIVE LEARNING AND DEVELOPMENT

Almost all explanations in the field of creativity share the belief that creative explorations should primarily be considered as self-directed, higher-order knowing activities, in which the knowing system is determined to achieve a significant transformation in the existing body of knowledge (Feldman, 1989). This transformation gives rise to ideas, insights, or problem-solutions that must be both novel and appropriate or functional in addressing wicked[16] problems — that is, complex, ill-defined problems with no clear solution criteria and no single correct answer (see Abdulla & Cramond, 2018; Hennessey & Amabile, 2010; Mumford et al., 1994; Runco, 2022a; Sternberg et al., 1999).

Accordingly, not all constructive activity or novelty should be classified as creative. In our model, creativity refers specifically to explorations that lead to significant, novel solutions that also achieve sufficient coherence and functionality within wicked problem contexts. As we intend to elaborate in this section, such constructive transformations are developmentally realized through self-directed learning processes that enable the knowing system to progressively differentiate, evaluate, and reorganize knowledge anticipatively in ways that support the emergence of creativity.

High-order self-directedness not only enables the system to manage its knowing procedures independently (see Christensen, 2004a, 2004b), but also provides motivation, allowing to it to sustain focus on its goals and persist in its tasks (Amabile & Pratt, 2016; Csikszentmihályi, 1988). In this paper, we focus specifically on higher-order self-directedness, as it characterizes the human capacity to recursively regulate, reorganize, and develop its own exploratory and evaluative activity. For instance, consider a doctoral student exploring ways to develop an original and effective contribution to knowledge (a dissertation). The nature of this exploration is typically wicked, and the process is increasingly recognized as central to creativity and innovation. The intense pressure and self-determination required in doctor research are fundamental to fostering innovation and developing an autonomous research mindset (see Baptista et al., 2015). These challenges intrinsically motivate doctoral students to increase their cognitive complexity — not only to accomplish research goals, but also to learn and develop general strategies for independent thinking. Thus, self-directedness serves as the driving force that enables doctoral students to metacognitively regulate their exploratory processes, ultimately leading to the construction of ideas that support their development as autonomous creative thinkers.

For intrinsically motivated knowing systems, creative exploration becomes an adaptive necessity (Feldman, 1989; Hooker, 2018), which has no room for trial and error (see references in footnote 16). However, the outcomes of creative explorations in (wicked) task environments are inherently uncertain—almost blind in nature (see D. T. Campbell, 1960). Task environments constrain knowing systems from forming ideas in advance, and when ideas do emerge, they can often prove dysfunctional for the system’s goals.

To cope with such difficult and uncertain explorations, self-directedness integrates learning and developmental functions into creative explorations. Self-directed learning and development guide the system in avoiding failure but also enable it to achieve significant transformations in knowledge constructions (see Feldman, 1999). Empirical studies confirm this strong link between self-directed learning and creative explorations, particularly in competitive work environments where individuals must confront wicked problems (see e.g., Liu et al., 2023; Morris, 2020).

Thus, *creative explorations can be modeled as trials aimed at achieving genuine knowledge constructions —processes that should prevent system failure even though they may ultimate prove inappropriate for the system’s goals*. In each one of these trials, self-directed learning and development operate on the interaction state[17] of the knowing system (see Fig. 1, Part a). As the knowing system creatively explores the task environment, learning progressively tries out transformations within the system’s current state, searching for novel yet appropriate ways of interaction (R. L. Campbell & Bickhard, 1992). These explorations may result in a potential creative “problem-solution”, a creative idea or an opportunity. This recursively constructive process gradually forms an idea trajectory (see Fig. 1, Part b).

To overcome the uncertainty of these “blind” trials and prevent the system from non-creative trial-and-error encounters, self-directed learning and development integrates anticipatory functions. Self-directed Anticipative Learning and Development[18] (SDAL) represents a higher-order knowing capacity (see Table 1 presents the most important facets of SDAL) shaped by the integration of anticipatory error-possibility[19] loops and reactive error-feedback loops and meta-loops. Anticipatory constructions enable proactive exploration of possible interaction outcomes, structuring trajectories before actual deviations occur.

Error-feedback loops operate reactively, detecting deviations from goal-states in real time and guiding corrective learning and reorganization (see Bickhard, 2024; Christensen & Hooker, 2000a; Hoffmaster et al., 2018). Meta-loops extend this regulation across hierarchical levels of knowing, enabling both proactive and reactive modulation of ongoing exploration based on the evaluation of long-term developmental consequences. Through this integrated mechanism, SDAL can proactively evaluate preparatory changes in interaction states — modifying exploration toward greater novelty — and reactively modulate the effectiveness of ongoing activities in response to detected deviations (see Christensen, 2004b; Farrell & Hooker, 2007a, 2007b; Hooker, 2017, 2018). This dual modulation enables SDAL to support both the creative expansion of interaction possibilities and the stabilization of successful trajectories through real-time learning and developmental reorganization.

At their core, these anticipatory error-possibility loops enable differentiation through embedded anticipative evaluation and selection processes. Anticipative differentiation enables an evolving context sensitivity allowing the system to progressively differentiate increasingly complex conditions within the task environment— conditions that correspond to representations of goal-states[20] (see Bickhard, 1988; Bickhard & Campbell, 2003; D. T. Campbell, 1960).

As context sensitivity evolves, ill-defined goals can be further differentiated into groups of more manageable (sub)goals, improving the understanding of the selected goals. For instance, doctoral students anticipatively differentiate between various knowledge resources, forming multiple highly abstract research goals that they then break them down into more manageable sub-goals. This process allows the student to formulate and refine an ill-defined hypothesis by setting hypotheses, testing conditions, or identifying key components. As context sensitivity enhanced, students not only differentiate additional research goals but also refine their understanding of their content. Reference values (known also as correctness or selection criteria) are an important aspect of goal-setting, as their selection determines the goal’s content. Essentially, reference values specify the conditions under which a goal-state is appropriately achieved (see Carver et al., 2015).

However, an evolving sensitivity to context corresponds to an evolving capacity for self-regulation. This capacity enables the system to become more adaptable, guiding the selection of contextually appropriate ways to approach differentiated goals. These selections are modulated through anticipative evaluations — that is, by how the system assesses the potential relevance or success of each trajectory before it unfolds (R. L. Campbell & Bickhard, 1986). Through anticipatory error-possibility loops and reactive error-feedback loops and meta-loops, SDAL recursively estimate the novelty and appropriateness of ongoing constructive processes by detecting the degree to which the new interaction state may deviate from the goal-state (see Christensen, 2004b; Farrell & Hooker, 2007a, 2007b; Hooker, 2017, 2018). Reference values aid SDAL loops to specify the degree of deviation and categorize the idea trajectory as adequate or inadequate (see Carver et al., 2015). These value-rich anticipative outcomes allow SDAL to correct or avoid errors before they occur, thereby ensuring the continuity of creative exploration.

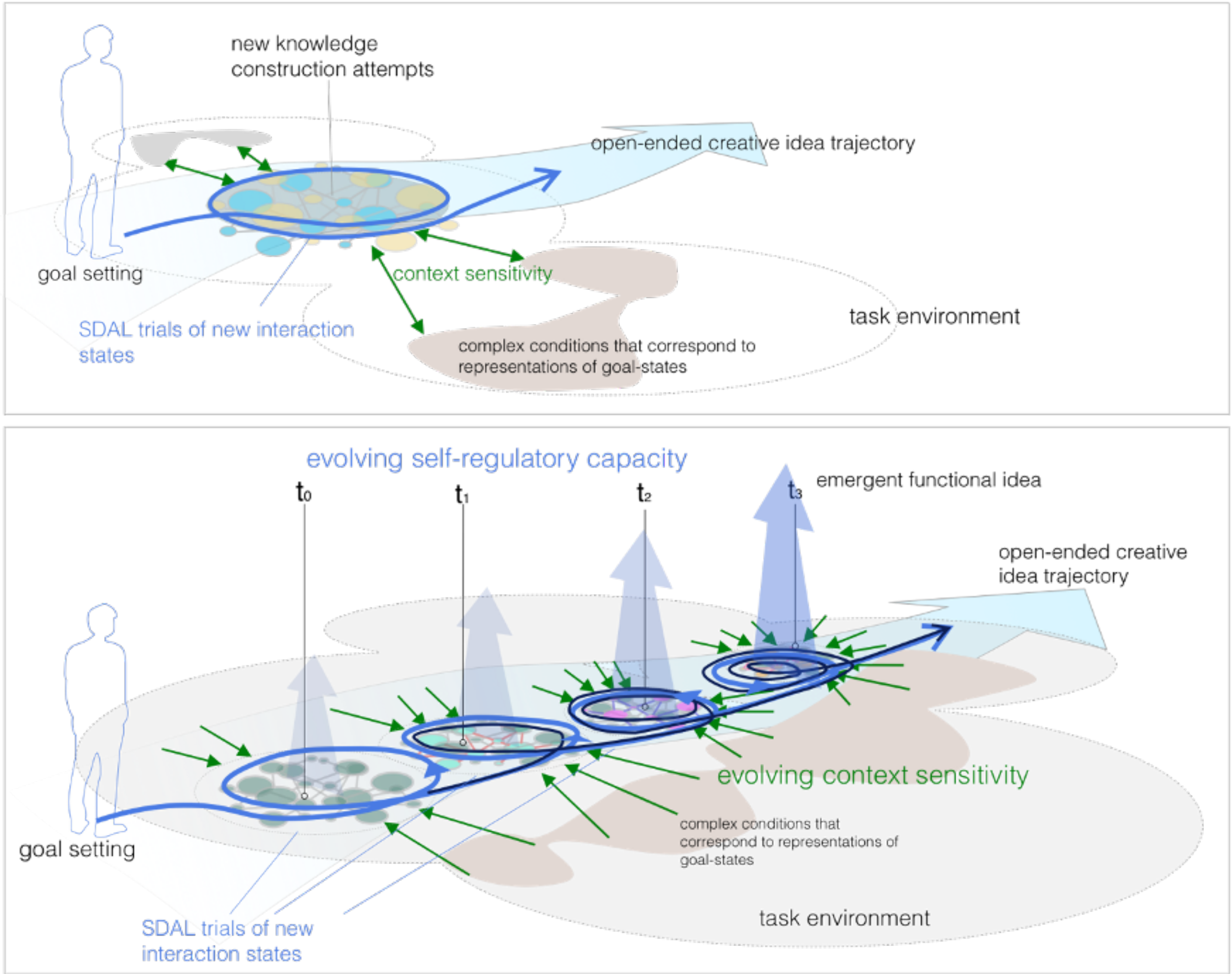
Continuing with our example, doctoral students can develop a sophisticated capacity to assign value to theories or research tasks by using epistemic values as reference values. This enables them to assess the novety and appropriateness of their research and, consequently, adjust their learning procedures to improve their exploratory performance.

As we further explain in Section 3.1, the evolution of anticipative differentiation and selection is directly related to the system's development (Feldman, 1999) providing an anticipatory, open-ended nature to creative ideas (Amabile & Mueller, 2008; Buchanan, 1992; Dorst & Cross, 2001). Each SDAL trial within the idea trajectory indicates to the doctoral student a future-oriented innovative state of affairs regarding the task environment. These indications trigger, enable, or drive the formation of representations of how a scientific explanation could be constructed if a specific idea trajectory is pursued. Consequently, the entire creative exploration becomes anticipatory and open-ended.

When SDAL trials progressively indicate that the constructed interaction state is deviating less from the goal-state, a progressive "insight" about the idea emerges. This particular moment, is often accompanied by the experience of "something clicked," by a feeling of "Eureka," commonly referred to as the "aha-insight moment", which marks that successful construction of new knowledge (D. T. Campbell, 1960; see also Topolinski & Reber, 2010). It is the moment when doctoral students can perceive research opportunities in a task environment that prior SDAL trials were unable to detect.

However, as this new idea trajectory reduces the uncertainty —gradually fulfilling the ill-defined goal-state— new knowledge emerges, further evolving the system's differentiation and selection capacity. At this point, additional goal-states can be detected, and new opportunities can be tried out, aiming at higher degrees of novelty and appropriateness. In this framework, goal-success in creative explorations is merely a momentary instance within an ongoing, open-ended creative idea trajectory (see Fig. 1, Part b).

Part a



Part b

Fig. 1 Part a: Novel and functional ideas are new knowledge constructions that emerge out of SDAL trials as the knowing system creatively explores the task environment forming gradually an open-ended creative idea trajectory. Part b: Within the open-ended creative idea trajectory the knowing system progressively evolves its capacity to differentiate in the task environment even more goal-states and accordingly to evolve its adaptability to attain these differentiated goal-states. These new differentiations correspond to SDAL trials through which the system is prepared for multiple interaction states that lead to novel and functional ideas.

In cases where uncertainty remains high, SDAL trials indicate that the constructed interaction states show high grades of deviation from the goal-state. To navigate with such uncertainty, SDAL does not require the knowing system to be an expert in a domain to construct creative opportunities. Instead, SDAL supports knowing activity in a way that allows systems to proceed with creative explorations using the resources available to them, thereby following a self-scaffolding practice (see Bickhard, 2007; J. D. Robinson & Persky, 2020).

SDAL trials must overcome uncertainty by shifting the ideation to higher levels of knowing. This represents a developmental process, where learning metacognitively manages and integrates information from multiple sources beyond what the system initially realizes it knows in lower levels (Loeng, 2020; Mentz & Lubbe, 2021; L. B. Smith & Thelen, 2003). This process continues until new, more stable idea trajectories are constructed (see Amabile, 1989; D. T. Campbell, 1960; Csikszentmihályi & Robinson, 2014; Hausman, 1975; Kaufman & Baer, 2006; Sawyer et al., 2003).

Such self-scaffolding practices require an increased sensitivity[21] to context — not only to external features of the environment, but also to the system's own evolving constructive history. This sensitivity enables the self-scaffolder to detect which contextual features are relevant for regulating and refining goal differentiation, thereby supporting the emergence of structured interaction states that form idea trajectories. Neurological studies suggest that while the anticipative differentiation of these idea trajectories start very early in the knowing activity, it remains indirect, as it involves both cognitive and metacognitive loops (Schomaker & Meeter, 2018).

Assigning anticipatory values to these idea trajectories enables them to be progressively differentiated into adequate and inadequate ones. The former are expected to promote, while the latter to block idea trajectories. Inadequate trajectories are metacognitively suppressed to reduce unwanted results during ideation (see Bickhard, 1992b; Simon, 1977; Wegner, 1994). Suppression keeps these unwanted knowing resources largely excluded from SDAL trials, though they remain in a high-activation state for future trials. By suppressing unwanted trajectories, other previously less relevant idea trajectories may now rebound as adequate (see Bickhard, 1992a, 2005, 2007).

For example, some scientific evidence which seems unnecessary for leading the doctoral student to a novel conclusion may not be transformed into an argumentation and is temporarily suppressed. This process allows other high activated evidence to resurface, as relevant, thereby enhancing idea construction. The remaining idea trajectories are then integrated, forming a new, more stable, more appropriate branch of idea trajectories, which progressively deviates less from the goal-state. Studies in creative problem-solving over recent years have identified this suppression mechanism during the incubation stage, suggesting that it may provide further insights into creative explorations (for a review see Gilhooly et al., 2015; Sio & Ormerod, 2009).

In this way, the representation of a novel and functional idea is modeled as an emergent result of a sequence of self-directed anticipative learning and developmental trials that progressively construct an idea trajectory. Within such dynamic constructions, the knowing system is intrinsically compelled to evolve its capacity to anticipatively differentiate goal-states and anticipatively select the most optimal interaction states as an adaptation to uncertainty.

As a result, creative explorations are modeled as a brunch of dynamic idea trajectories, the novelty of which is an aspect of the evolution of anticipative differentiations, and their appropriateness is an aspect of the evolution of anticipative selection, making thus development a fundamental aspect of creative explorations.

This means that any model that describes the functional connection between aesthetics and creativity should not only involve self-directed anticipative learning functions but necessarily include development as well. And as we argue next, development further enhances the capacities required for creative explorations.

Table 1 SDAL is one of the main goals of educating adult creative thinkers. It usually takes place outside of the traditional classroom, fitting to the way creative thinkers learn in their working environments. The following table shows the multifaceted properties of Self-directed Anticipative Learning (for a review see Loeng, 2020; Morris, 2019).

<table>
<tr><td colspan="3">Self-directed anticipative learning (SDAL)</td></tr>
<tr><td colspan="2">Aims at</td><td>adult education,
professionals,
students (in design thinking) which expect to be independent in decision-making,
personal responsibility in the teaching-learning process,
personal responsibility in one’s own thoughts and actions,</td></tr>
<tr><td colspan="2">Practiced</td><td>both inside and outside of formal school environment,
when teachers are involved, they should be facilitators of learning, not transmitters,
self-designed learning environment,</td></tr>
<tr><td colspan="2">Learning styles</td><td>diverging learning combines concrete experience and reflective observation,
assimilating learning combines abstract conceptualization with reflective observation,
converging learning combines abstract conceptualization with active</td></tr>
<tr><td rowspan="2">Learning trajectory</td><td>synchronic processing</td><td>the knowing and learning processes are recursive,
the learner monitors the conditions of interaction (current psychological and physical state, capacities, environmental conditions, etc.),
the learner uses intrinsic motivation to learn,
the learner defines, executes, and completes the learning task,</td></tr>
<tr><td>diachronic meta-processing</td><td>the knowing and learning processes are meta-recursive,
the learner monitors the knowing and learning activities,
the learner generates of high order anticipative structures,
the learner diagnoses general learning needs,
the learner makes (long term) plannings to find suitable resources for learning,
the learner formulates and manages the learning goals,
the learner prioritizes what it needs to be learned next,
the learner monitors how learning is best accomplished,
the learner evaluates the learning process,</td></tr>
</table>

3.1 CREATIVITY AND DEVELOPMENT

SDAL trials operate in the interaction state of the knowing system according to two aspects of knowing: interactive knowing (first-level) and reflective knowing (higher levels), also referred to as the synchronic and diachronic dimensions of knowing (R. L. Campbell & Bickhard, 1986; Rueger, 2000). The interactive (synchronic) aspect, as explained in the previous section, concerns the exploration of immediate opportunities based on indications from the task environment. It involves first-level SDAL trials, which construct idea trajectories that vary in value, thereby shaping the ideation flow (see Fig. 2, Part a:1st level of knowing).

However, the quality of this flow as a unified meaningful trajectory cannot be experienced unless a higher-order, diachronic aspect of knowing has evolved. Experience itself emerges as a diachronic organization of knowing, and it demands hierarchical levels of regulation that provide the foundation for the system's ability to explore, learn, and evolve its own properties (Feldman, 1989). Diachronic processes constitute the basis of reflective knowing (higher levels): they function as metaprocesses that monitor, control and reorganize lower-level cognitive activity. Each higher level interacts with the next lower one, just as the first level (interactive knowing) engages directly with the task environment. These hierarchical interactions are realized through SDAL-based regulations that support "reflecting on one's own way of reflecting" — a process widely known as reflective abstraction (R. L. Campbell & Bickhard, 1986; Fisher, 1998).

Regarding to our example, doctoral students are not confined to synchronic SDAL regulations, which operate at the level of interactive knowing (first-level). These involve investigating the research field, differentiating multiple research goals and opportunities, and working toward innovation. Diachronic SDAL regulations, by contrast, correspond to reflective knowing (higher levels) — developmental processes that support the reorganization of exploratory strategies and the long-term integration of knowledge (R. L. Campbell & Bickhard, 1986). These higher-order processes are essential for enabling doctoral students to evolve into autonomous researchers capable of regulating and refining their own learning trajectories.

Through reflective abstraction, doctoral students can construct higher-order meanings (e.g., understanding the deep meaning of notions like "autonomy in living systems") while they experience qualitative results that allow them to assess their overall capacity in managing the research flow of their dissertation. This reflection enables them to evaluate the trajectory of their research and estimate its future prospects. Diachronic reflections can answer questions like "How good am I at constructing a research hypothesis?", or "How effectively do I select epistemic values?", or "How well do I develop my own research methodology?", or "How can I improve my ability to assess the quality of my investigation results?". By engaging in diachronic SDAL regulations, doctoral students not only refine their research strategies but also enhance their ability to navigate creative explorations, ultimately fostering autonomy and expertise.

In other words, relating to our example, development facilitates doctoral students to increase their autonomy and to monitor —from multiple meta-levels of understanding— what is already known, what has been found, how novel this knowledge is, and what remains unknown. This awareness can evolve their capacity to constrain the construction of further opportunities for innovation, for example, by setting proper or new reference values that enhance the regulation of suppression and promotion. Thus, we understand development as the diachronic consideration of SDAL, operating within its long-term framework and with its long-term properties (Bickhard, 2006).

However, development does not only facilitate metacognitive monitoring and control of lower-level idea trajectories. As we have explained, self-scaffolders, like doctoral students, are forced through suppression to further develop their SDAL trials in higher levels of knowing. This development expands the degrees of freedom of their creative explorations, thereby evolving their differentiation and selection capacity. As a result, development broadens the way the task environment is perceived (see Fig. 2, Part a: expanded task environment).

By evolving the differentiation capacity, new goals[22] emerge across the hierarchical levels of knowing (Carver & Scheier, 2013; Sternberg & Lubart, 1991). These higher-level goals are not merely more abstract but also serve a qualitatively different regulatory function: they operate as reference values that guide and constrain lower-level SDAL explorations. This structure aligns with established models of hierarchical goal organization, where higher-level system concepts organize principles and task-level goals by modulating how the system evaluates success and relevance across contexts. Higher-level goals foster the emergence of novel higher-level creative opportunities. This explains why doctoral students gradually experience a shift from a narrow to a broader understanding of their research field overtime, opening the door to new research opportunities. Development expands the way theories are approached and understood during creative explorations. Goals can be now approached from multiple perspectives (e.g., ethics, responsibility, sustainability, social innovation) that the student was previously unable to perceive in lower-level SDAL trials.

Considering that goals are also structured across levels of abstraction, the interrelations between higher-level goals and lower-level goals are critical for SDAL trials to distinguish adequate idea trajectories from inadequate ones at each level. Groups of lower-level goals can in principle function as reference values in higher-level SDAL trials (Carver & Scheier, 2013), thereby determining how a more abstract goal can be appropriately approached and ultimately achieved (see Fig. 2, Part b). This means that goals at different levels are not only distinguished by their degree of abstraction, but also by their function: higher-level goals regulate, constrain, or redefine the relevance of lower-level goals, serving as evaluative structures within the system’s developmental organization.

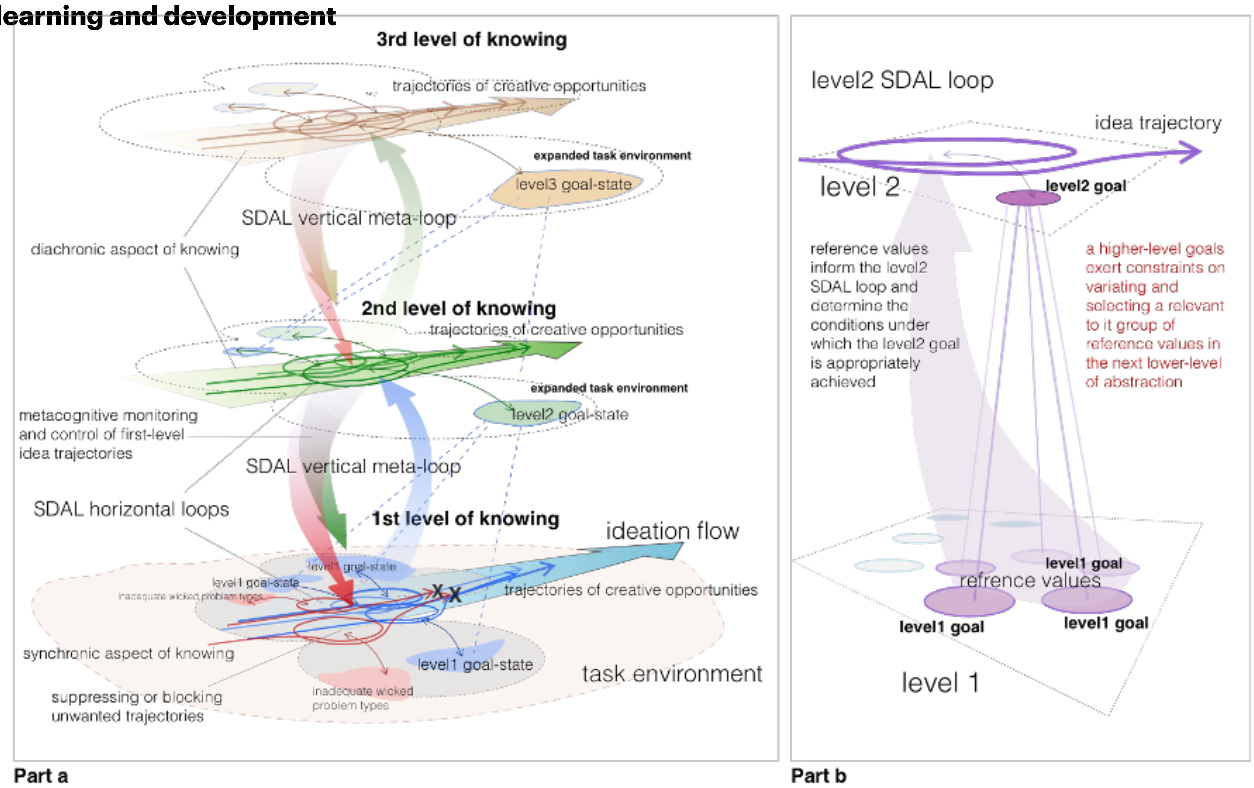


Fig. 2 Part a depicts how synchronic and diachronic aspects of knowing are interrelated within hierarchical levels of knowing. Particularly depicts (a) how horizontal and vertical SDAL loops facilitate the construction of idea trajectories across hierarchical levels of knowing suppressing knowing resources, and (b) how the perception of the task environment expands in higher levels of abstraction. Part b attempts to depict how goals are interrelated between two levels of abstraction facilitating the construction of higher-order idea trajectories.

Creative explorations unfold using two interconnected types of SDAL loops: the horizontal loops and the vertical meta-loops (see Fig. 2, Part a). Horizontal loops support both synchronic and diachronic aspects of knowing, functioning to estimate possible deviations from the goal-states at each level (Efklides, 2008). There is strong evidence that anticipatory explorations like affectivity and emotional conceptualizations are emergent constructions of horizontal loops operating across the hierarchy (see Barrett, 2012; Bickhard, 2000; Carver & Scheier, 2017). Thus, emotion is not a single-level phenomenon. Horizontal SDAL loops at each level of knowing generate affective modulations appropriate to that level's degree of abstraction — from concrete interactions to abstract conceptual evaluations. These anticipative constructs help detect indications of interaction potentialities and outcomes and guide exploration locally within each level. In contrast, vertical SDAL meta-loops generate meta-feelings[23] which provide the system with feedback about the overall quality and progress of its exploratory activity.

Values formed by horizontal loops establish a complex network of preferences in idea trajectories, and, as we will argue in Section 4, these value-rich preferences shape an aesthetic and anticipative sense about the situation —an aesthetic feeling about those aspects of the situation that can serve student's goals during this exploration.

In contrast, SDAL vertical meta-loops support only diachronic aspects of knowing, as they always connect two subsequent levels of knowing. These loops use higher-level goals and perform top-down corrections in horizontal loops (see Fig. 2, Part a) (see Efklides, 2008; for neurological evidence see Ivancovsky et al., 2024). In cases of high uncertainty, vertical meta-loops compel self-scaffolders to attempt bottom-up changes in the interaction state, forcing the idea trajectory to develop its effectiveness.

Experiences of qualities like feelings of difficulty (lack of processing fluency), problem-solving knowing, familiarity, novelty, confidence, and satisfaction, arise from vertical meta-loops (Efklides, 2006b; Ivancovsky et al., 2024). These vertical meta-loops provide the knowing system with a meta-level sense of the overall quality of the ongoing creative exploration: "How does it feel to be a creative doctoral student?", or "How creative am I?" and "How creative I eventually become?". The level of the selected reference values, determines the extend to which a creative idea can be classified within established categories like that of "mini-c" ideas (Kozbelt et al., 2010; Runco, 1996), "little-c" or "Big-C" ideas (R. Beghetto & Kaufman, 2007) or ideas that ultimately fail to be considered creative.

It is important to clarify that experience requires at least two levels of knowing: a first-level process and a higher-level reflective process that organizes or monitors it. Therefore, what operates at the level of interactive knowing (first-level) is not an aesthetic experience but a pre-reflective aesthetic indication — a value-rich, affective modulation that helps guide ideation without becoming conscious experience. These modulations shape the direction of creative exploration, but they only become experiences when reflected upon through higher-level SDAL processes. What we refer to as "aesthetic experience" is an anticipative, meta-level sense of how well the creative exploration is unfolding in relation to one's goals. This sense, emerging at level 2 or higher, builds on value-rich modulations at level 1 but becomes experience only through reflective abstraction (see Section 4).

These qualitative experiences have a direct effect on planning (Sitzmann & Ely, 2011). They provide self-confidence to doctoral students, encouraging them to continue their exploration and set further challenges. Meta-anticipatory constructions such as estimations of solution correctness, the selection of effective learning strategies, the effort required to learn, and the needed for learning activities all contribute to improve their creative thinking (Efklides, 2008; Sitzmann & Ely, 2011).

In the following section, we introduce the Interactivist-Constructivist model of Aesthetics, which redefines aesthetic knowing as a value-rich, anticipative regulatory function within the knowing system. This model integrates learning, development, and creative exploration, offering an alternative to traditional modular approaches by explaining how aesthetic sense supports transformative ideation across levels of knowing.

4 THE INTERACTIVIST-CONSTRUCTIVIST MODEL OF AESTHETICS

The Interactivist-Constructivist model of Aesthetics is based on the Interactivist-Constructivist paradigm, which promotes a deeply naturalistic framework of cognition (see Arnellos & Xenakis, 2017). It involves fundamentally different assumptions about action-selection and knowledge construction than those made in standard faculty models within cognitive science, and psychology. Moreover, it is based on metaphysical framework that diverges significantly from the domain-specific and epistemically elitist conception of the aesthetic mind — a view aligned with Continental aesthetic philosophy and dominant correspondence-based models in the psychology of aesthetics, in which aesthetic correctness is seen as inaccessible to learners and dependent on expert-defined standards.

Rooted in the organizational framework of the evolution of autonomous agency, the Interactivist-Constructivist model of Aesthetics provides an explanatory model of knowing processes that exhibit a self-directed sensitivity and anticipative exploratory activity organized to construct an "(interactive-)aesthetic sense of the situation", *i.e., to interactively appreciate*[24] *the aspects of the task environment that would probably lead to interaction opportunities or threats*[25] (see Xenakis & Arnellos, 2015, 2017; Xenakis et al., 2012; Xenakis, 2018; Xenakis & Arnellos, 2013). Based on the functional role of emotions in aesthetic encounters (Xenakis et al., 2012), emotions in this model are not integrated as metaprocesses in the sense of reflective knowing, but as foundational anticipative modulations constructed through horizontal SDAL loops across all levels of knowing (Xenakis, 2025). As argued by Bickhard (2000), emotions emerge as internal interactions with uncertainty, supporting the system's stabilization and learning by guiding action selection before reflective awareness. Barrett and Bar (2009) similarly show that affective predictions function at the level of perception and cognition as value-based constraints that guide the formation of ongoing perceptual and cognitive trajectories. In this sense, emotions are functionally embedded in ongoing interactive regulation within interactive knowing (first-level). However, following Efklides (2006a), such anticipative constructs can facilitate reflective knowing (higher-level cognition) in the form of meta-feelings when emotional signals are taken up into vertical SDAL loops, enabling reflective evaluation. This is also consistent with Carver and Scheier's (2017) model of self-regulation, where affect signals discrepancies in goal pursuit but only becomes metacognitive when monitored reflectively. Therefore, what we refer to as an "aesthetic sense" is not a primitive emotional response, but an anticipative evaluative modulation that integrates pre-reflective affective dynamics with reflective feeling of how the creative exploration unfolds over time, thereby giving rise to the "aesthetic experience."

Thus, aesthetic sense is modeled as an inherent aspect of the knowing activity, which facilitates the effectiveness and the evolution of the differentiation and selection capacity of the knowing system. It emerges as a progressive outcome of horizontal and vertical SDAL trials and serves to provide value-rich[26] anticipative constructs, which signal the knowing activity regarding the degree of prospects that ongoing idea trajectories have in relation to aspects of the task environment (see Xenakis et al., 2012; Xenakis & Arnellos, 2014).

In cases of uncertainty, the aesthetic sense signals vertical SDAL trials to evolve the effectiveness of weak ideation trajectories, thereby shifting the ideation process to higher levels of knowing. Thus, the aesthetic sense facilitates exploratory activity, forming both short-term (synchronic) and long-term (diachronic) preferences regarding (interaction) affordances (Xenakis & Arnellos, 2013). It is important to clarify that in our model, uncertainty is not an object of anticipation, but an emergent property of interaction — a condition in which the system does not yet have a viable trajectory for resolving its anticipations. Emotions do not function to detect uncertainty as such but are constructed in response to the breakdown of interactive regulation, helping to guide the selection or restructuring of idea trajectories under unresolved conditions (Bickhard, 2000; Xenakis et al., 2012).

In other words, during creative exploration, the aesthetic sense allows the individual to evaluate whether aspects of the task environment — or the idea itself — are likely to afford meaningful progress and are worth pursuing further. For example, it helps a doctoral student assess whether a research idea is sufficiently creative for publication as it stands, or whether it needs further development to increase its novelty. At the first level of knowing, the student engages interactively with texts, note-taking, writing fragments, and exploratory diagrams. Horizontal SDAL loops support the detection of certain indications, and the aesthetic sense signals when an idea feels “promising” or “unclear.” This aesthetic sense regulates ideational flow, helping the student to self-scaffold and explore or suppress different directions within the first levels that establish a valid research question — without yet engaging in reflection on how to solve it. First-level knowing is fundamentally skillful and procedural.

As the idea gains coherence, the student constructs a viable research question, and meta-feelings of having found a promising direction begin to emerge. This creative development activates second-level knowing, where vertical SDAL loops support reflection on whether the question satisfies broader academic expectations or aligns with more abstract intellectual goals than those addressed in level one. Notably, the reference values for these more abstract goals are often established during the earlier first-level explorations. Meta-feelings such as confidence, uncertainty, or difficulty emerge as reflective evaluations regarding the progress of the ideational trajectory.

Once self-scaffolding forms a stable conceptual trajectory toward a solution, the student re-engages first-level processes — refining arguments, clarifying logic, improving writing — while second-level knowing continues to monitor and evaluate structural coherence. If the student begins to consider how their work contributes to the field or opens up broader theoretical directions, third-level knowing is activated. At this level, new abstract goals emerge, such as constructing a broader theoretical framework or contributing to interdisciplinary discourse.

Here, reflective abstraction evaluates not only the quality of the idea, but also the student's evolving research identity and epistemic positioning within the academic landscape.

At this point, it should be made clear that (interaction) aesthetics are not treated as a peripheral or decorative layer of experience, but as a functional aspect of the knowing ontology. They contribute to the entire preparatory procedure leading to goal success — in this case, the emergence of creative ideas under conditions of uncertainty. Specifically, interaction aesthetics refer to the system's ability to construct and evaluate value-rich, anticipative judgments about ongoing interactions: whether particular idea trajectories of contextual affordances, or exploratory paths are likely to succeed, fail, or require modulation.

Unlike models that isolate aesthetics in terms of perception, emotion, or innate preference, the Interactivist-Constructivist account treats aesthetics as a systemic, evaluative dynamic embedded in the learning process itself. Aesthetic judgments are not about passively identifying beauty or balance; they are about sensing which directions in the ideational space are worth pursuing, based on the organism's interaction history, its adaptive goals, and the evolving structure of its cognitive organization. As such, aesthetics become a form of anticipative regulation — guiding creative development by modulating attention, direction, and exploratory commitment. Importantly, (interaction) aesthetics is not introduced as a primitive concept, but emerges as a functional aspect of self-regulation — which itself develops through recursive SDAL processes. It plays a regulatory role in guiding ideational differentiation and interaction selection, and is fully analyzable within the Interactivist-Constructivist framework.

This means that interaction aesthetics cannot be reduced to specific mental faculties such as emotions, perceptions, conceptualizations, or representations. Contrary to Parsons (2016), who suggests that aesthetics are an extra or isolated component of creative thinking, we argue that (interaction) aesthetics are not separate cognitive functions, but are inherently embedded within the exploratory dynamics of the knowing ontology. Their functional role is not merely to anticipate or react to uncertainty, but to provide value-rich evaluative modulation that supports the system's ability to creatively navigate and regulate ideational trajectories in the resolution of ill-defined problems. This does not involve arbitrary expectation or affective regulation in the allostatic (see Barrett et al., 2015) or homeostatic sense (see Damasio & Carvalho, 2013), but rather a structured, developmental process of differentiating directions that hold potential for both novelty and appropriate impact (Xenakis, 2018; Xenakis et al., 2012; Xenakis & Arnellos, 2012).

The content of an (interactive-)aesthetic sense is a dynamic construct (see Xenakis et al., 2012; Xenakis & Arnellos, 2014) and should not be mistaken for fixed correspondences between "aesthetic properties" in the external world and dedicated modules in the mind. This means that aesthetics are not part of our physical surroundings, existing separately from the knowing system's mind (Xenakis & Arnellos, 2017). In the same way that, within the Interactivist-Constructivist framework, indications of interaction potentialities are not treated as static pointers — that is, fixed internal structures that correspond to objects or properties in the world — interaction aesthetics cannot be reduced to static features like symmetry. Instead, aesthetic sense is a situated, observer-dependent construct that inherently embrace normativity and interaction error (Xenakis & Arnellos, 2013). In our framework, normativity refers to the system's anticipative evaluative activity — its ability to guide idea trajectories based on interactional relevance and potential success. This evaluative orientation, when embedded in creative exploration, constitutes what we call interaction-aesthetic normativity.

As a result, (interaction) aesthetics do not emerge from a separate cognitive layer or modular function that can be added as an extra feature in the idea trajectory. For the Interactivist-Constructivist model of Aesthetics, there is no distinction between traditionally defined (artistic) aesthetic and non-aesthetic (everyday) experiences. All creative explorations involve an aesthetic dimension, insofar as they require the anticipative evaluation of which directions are worth pursuing under uncertainty. However, the contents of the aesthetic sense — that is, the affective tone, criteria, or experiential qualities — differ depending on the domain (e.g., artistic or scientific) and the nature of the task. Consequently, returning to our example, the aesthetics of working in an artistic project and of creating a doctoral dissertation do not involve two distinct cognitive modes— one artistic and one everyday — but instead operate within a unified knowing ontology.

Certainly, the contents of an (interactive-)aesthetic sense during art-making, research-making or any other creative exploration differ. However, they are all part of a unified knowing ontology that provides knowing systems with different feelings and experiences of interaction-aesthetic normativity. Both doctoral students and artists are intrinsically motivated to anticipatively differentiate creative opportunities and to anticipatively select among them those that are expected to effectively resolve their personal interaction uncertainty.

However, this does not imply that SDAL trials cannot use domain-specific conceptualizations (e.g., principles of stylistic expressions, principles of artistic-social-political-ecological movements and trends, principles of ethics, etc.) within idea trajectories. These elements can serve as reference values for higher-order goals without reducing creative ideas to a distinct "aesthetic kind" (see Xenakis & Arnellos, 2017).

Finally, in contrast to contemporary single-level processing models of aesthetics, the Interactivist-Constructivist Model of Aesthetics provides an explanation that supports complex, multilevel aesthetic experiences, facilitating the entire creative exploration in various ways. As demonstrated, across the hierarchical levels of knowing, SDAL horizontal loops assign anticipatory values to idea trajectories that differ in abstraction (e.g., affective, high and higher order emotional values). Accordingly, SDAL vertical meta-loops, provide a meta-sense about the quality of this exploration, which also varies in abstraction across the hierarchical levels of knowing (e.g., values about success, progress, difficulty, uncertainty, novelty, problem-solving capacity, etc.). The quality that forms the metacognitive experience of having an interaction-aesthetic sense constitutes the aesthetic experience of how this creative exploration unfolds. This metacognitive experience involves an anticipative meta-sense about the prospects of exploration in relation to the system's goals and meta-goals.

As a result, the content of an aesthetic experience can vary across the hierarchical levels, depending on the abstraction of the selected goals. Consider the case of a doctoral student experiencing a positive aesthetic sense at lower levels of knowing —for example, achieving anticipated results in a study, leading to meta-feelings of success. However, at higher levels of knowing, where the student seeks broader confirmation of creativity from the research community, uncertainty may persist. As the student progresses toward higher-level goals (e.g. to present the idea, to publish the idea, to gain citations from this the idea, etc.), the aesthetic experience may still be characterized by an increased uncertainty.

This feedback of uncertainty leads the whole knowing activity to the process of development. The student must enhance meta-level awareness of the difficulties associated with achieving higher-level goals and refine the reference values that define those goals. This process directly influences the strategy of creative exploration and may reshape the content of lower-level goals in the synchronic level of knowing. At this stage, the doctoral student must enhance their understanding of what it means to express, write, and communicate an innovative idea clearly and accurately. This necessitates incorporating reference values relates to scientific writing, initiating new SDAL trials in the synchronic level—by actively writing down the idea.

In this way the doctoral student enhances their awareness and understanding of the strategies themselves, including their power and limitations (Kuhn, 2000). This, in turn, fosters a powerful aesthetic experience regarding their general creative capacity. They aesthetically experience that while having a good idea is valuable, it requires further effort to successfully defend a dissertation.

Our argument is that in wicked task environments (interaction) aesthetics are inseparable from creative explorations. Aesthetics not merely integrate into the learning and developmental processes—they are themselves integrated into these functions, actively contributing to significant transformation in the existing body of knowledge.

This functional integration enables the knowing system to evolve its interactive-aesthetic sense alongside other essential cognitive activities. As a result, the system expands its entire creative exploratory capacity, thereby opening the door to further creative opportunities.

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FOOTNOTES

[1] The term “Continental aesthetics” refers to the tradition of aesthetic theory associated with Continental philosophy, particularly post-Kantian European thinkers such as Hegel, Schopenhauer, Heidegger, and Gadamer. These approaches often emphasize the intrinsic connection between artistic form, aesthetic experience, and philosophical reflection, contrasting with analytic aesthetics’ focus on clarity, categorization, and linguistic analysis.

[2] The term “creative devices” is neither based nor offers any epistemological explanation. It is mostly known in Continental literature as aesthetic attributes, features or properties that determine the existence of “beauty” in things. In sort, aesthetic properties are by assumption aspects of reality (e.g., of artworks) that exist independently of the human mind. We will further discuss their nature in section 2 since they are considered the core of the standard explanations in aesthetic theory.

[3] Following the seminal work of Feldman (1999), we use the term “creative explorations” than “creativity” to give an emphasis on the thinking processes that the knowing system enables in order to investigate resources (internally as well as externally), that will bring to the system new knowledge to achieve a creative result.

[4] As we will further explain in section 3, creativity is generally defined as the production of novel, but also appropriate, or effective ideas (Amabile et al., 2005). The terms “appropriateness” and “effectiveness”, denote functionality; an idea or its product should be functional for the system it serves. It should work well, be useful, logical, understandable, or provide value to the system (Runco & Jaeger, 2012).

[5], In “the modular mind” paradigm, the mind is understood as including a single-level, linear sequences of separate and independent psychological abilities, which have their own distinct innate physical properties that correspond with innate conceptualizations in the form of mental modular entities. See section 3 for a further analysis.

[6] The Interactivist-Constructivist (I-C) paradigm in cognitive psychology is a naturalistic framework for the evolution of agency and cognition in the living systems, based mainly (but not only) on the metaphysics of autopoiesis and constructivism (Bickhard, 2009a, 2009d, 2009b). I-C arose from works on the biological organization of living systems where action-selection emerges as a major organizational transition (see Bickhard, 2003, 2009a; Bickhard & Terveen, 1995; Christensen & Hooker, 1999, 2000b; Hooker, 1994). I-C has natural affinities with the organizational account of biological functions (see Moreno & Mossio, 2015), situated and dynamical approaches to cognitive science (see Barsalou, 2008; Thelen, 2002), and embodied, integrated and constructivist approaches to meaning, representation and emotions (Arnellos & Moreno, 2022; see Barrett & Russell, 2015; Pessoa, 2019; Piaget, 1956).

[7] The “task environment” involves classes of complex and dynamic situations and contexts. These are organizations of complex systems consisting of networks of actors and various infrastructures—all together coupled with goals. Cities are examples of such “organized complexity” of a task environment. It is within such complex and dynamic contexts that knowing systems plan their actions to accomplish their own goals. It is the goals of the knowing system that define a point of view about the task environment, and that allows a task environment to be delimited (Newell & Simon, 1972).

[8] Aesthetic properties are considered to be correspondences between physical elements of an object and aesthetic conceptualizations in the mind responsible for transforming an ordinary experience into an aesthetic one. Examples are materials aesthetics (see e.g., Marschallek & Jacobsen, 2022), the complexity in a composition of shapes (see e.g., Jacobsen & Höfel, 2002; Sammartino & Palmer, 2012), color combinations of harmony or similarity (see e.g., Schloss & Palmer, 2011), etc.

[9] This concerns a Kantian assumption that introduces a dichotomy between the aesthetic and the knowing activity as two totally distinct faculties. The aesthetic faculty is special since it ontologically differs from the faculty of cognition which has a purpose to know the world. In the standard doctrine of aesthetics, there are several works that still assume that the aesthetic faculty does not involve any kind of motivation to achieve some goal (see e.g., Makin, 2017; Marković, 2012).

[10] The notion “transduction” denotes a transformation from a form of energy, into another form of energy. For example, a system S is a transducer for a property P only if there is a state Si of the system that is correlated with P. Then P is directly detected by S. If P occurs, then Si occurs (Fodor & Pylyshyn, 1981).

[11] Encodings stand in a static one-to-one correspondence with the things that they represent. In general, encodings change the form and the medium of representations (e.g., a typed letter “A” stands in the sound of a spoken A). So, with the use of encodings information can be transferred along different channels (for an extensive analysis on innatism and encodism see Bickhard, 1991; Bickhard & Richie, 1983; Bickhard & Terveen, 1995).

[12] In Fodor’s (1983, 1985) modular theory, innatism refers to the assumption that domain-specific cognitive modules — including their input encodings — are pre-specified and hardwired into the architecture of the mind. These encodings are not learned or derived from interaction but are thought to function autonomously, quickly, and mandatorily in response to fixed features of environmental input. This innatist stance stands in contrast to constructivist or developmental approaches, which posit that such encodings emerge through learning and interaction.

[13] Since the modular framework is in contrast with the notion of “emergent representation”, to avoid misunderstandings, the term “concept” is used when we refer to the “modular” theory of mind instead of the term ”representation or emergent representation” that is used when we refer to interactivist – constructivist accounts (Barrett & Russell, 2015; Bickhard, 1997; Christensen & Hooker, 2000a; Clore & Ortony, 2013; Pessoa et al., 2021).

[14] We meet the term “disinterestedness” not only in “theories of taste” like that of Hume and Kant, but also in ”aesthetic attitude” theories as well as in works of philosophers like Schopenhauer, Shaftesbury, Alison, Croce, Bergson, Hutcheson, Burke, Bullough and several others (for a full discussion see Dickie, 1973; Guyer, 1978; Stolnitz, 1961, 1963, 1978; White, 1973).

[15] In modular theories of mind, encodings are assumed to be innate, domain-specific, and functionally encapsulated (see Fodor & Pylyshyn, 2015; Pylyshyn, 1980). Once the appropriate environmental input is detected, the corresponding module activates automatically. There is no evaluative mechanism for determining whether the activation was contextually appropriate, nor any developmental process for refining the encoding. As such, encodings are assumed to function without error under the proper triggering conditions — which is why, in these models, encoding failure is not conceptually possible.

[16] The main source of uncertainty in creative explorations is related to the *ill-defined and open-ended* nature of the wicked goals or problems (see R. A. Beghetto, 2019; R. A. Beghetto & Jaeger, 2022; Gabora & Steel, 2022).. In short, the most important attributes of wicked problems is that: (1) they are actively self-formulated during the exploration and they have no definitive formulation, but every formulation corresponds to the formulation of a solution, (2) solving a wicked problem is a “one shot” operation; there is no room for trial and error, (3) solutions to wicked problems are only normative (good or bad) and not descriptive (true or false, beautiful or ugly), (4) in solving a wicked problem there is no exhaustive list of permissible operations, (5) for every wicked problem there is always more than one possible explanation (6) problems and solutions co-evolve, (7) wicked problems have no stopping rules; the creative process does not tell you when to stop the exploration (see e.g., Dorst & Cross, 2001; Farrell & Hooker, 2013; Lönngren & van Poeck, 2021; Rittel & Webber, 1973). Accordingly, the task environments we consider in this paper are wicked.

[17] “Interaction states” correspond to new system organizations that are instances in the creative exploration and denote potential “creative ways of interaction”, “creative problem-solutions”, “creative ideas” or “creative opportunities”. Each of these terms will be used interchangeably in the text.

[18] SDAL is a multifaceted concept of learning and development that involves not only properties of knowing constructions, but also learning styles and teaching practices.

[19] The general structure of anticipative modulation and self-correction discussed here may appear similar to the Predictive Processing (PP) paradigm, which also emphasizes anticipation and error minimization (e.g., Friston, 2012). However, as Bickhard (2016) argues, the interactivist model diverges fundamentally: it does not assume representational priors or hierarchical Bayesian inference. Instead, anticipation is grounded in recursive interaction and developmental microgenesis. In our framework, normativity and representation emerge from the organism’s capacity to regulate its own interactive flow — not from prediction error calculated against fixed priors. Thus, SDAL-based anticipative regulation supports creative development by reorganizing trajectories, not minimizing surprise.

[20] The representation of a goal-state is another important dynamic aspect of the knowing ontology that should not be omitted. As we briefly explain in this section, aspects of goal setting, like reference values, determine the content of a goal-state, and their selection has a direct effect on learning trials (for a relevant analysis see Carver & Scheier, 2013; Sternberg & Lubart, 1991). Thus, goals involve representational content (in that they organize

anticipations and evaluations), but they are not themselves fixed or internalized representations in a static sense; they are anticipatively constructed organizational structures that regulate systemic engagement, evolve through self-directed learning, and restructure cognition across developmental trajectories

[21] As Bickhard (1992a, 2005, 2007) emphasizes, any successful self-regulating system must be context sensitive — not only to external interaction conditions, but also to its own prior constructions. In recursive constructivism, this sensitivity is what enables development, as self-scaffolding depends on the ability to detect and build on dependencies between earlier and current constructions. Therefore, context sensitivity is not just useful but structurally necessary for a system to scaffold its own learning and regulate its own developmental trajectory.

[22] One of the characteristics of a stage knowing model is that there can be an infinite number of emergent levels of knowing, and accordingly, an infinite number of goals that can be differentiated in each one of these levels. Similarly to Powers (1975), Carver and Scheier (1998) propose a three-level model. At the highest level (system concepts) "abstract values or goals" are related to the global sense of an idealized self, that is, of living in an ideal social ecosystem. They reflect more long-term, general aims that transcend specific situations and apply to multiple contexts. "Principle or concrete goals" often have sensible, desired, mainly short-term, outcomes which are achieved by particular actions in response to particular contexts. "Principles" are values or qualities like honesty, safety, freedom, responsibility. A lower-level involves "programs or active goals" that specify the tasks by which a principle can be attained. Someone enacts an active goal (partly) by enacting sequences of tasks.

[23] In this framework, meta-feelings are not reflective or deliberative judgments about prior emotional states, as in traditional metacognitive models. Rather, they are anticipatory evaluative modulations constructed through vertical SDAL loops. Meta-feelings arise when the system monitors the diachronic impact of an unfolding ideational trajectory — that is, how likely the current direction is to lead to meaningful development or goal alignment. These feelings (e.g., confidence, difficulty, satisfaction, uncertainty) are about the system's own ongoing processes and their projected outcomes. They play a regulatory role in creative exploration, helping the system refine its evaluative orientation without requiring explicit reflection or conceptual reasoning.

[24] We use the term appreciate deliberately to describe a value-rich evaluative sensitivity rather than simple forward-looking anticipation. In our framework, to appreciate an aspect of the task environment means to register its relevance, potential, or risk in guiding ideational differentiation — not merely to predict it. While anticipation denotes a temporal projection, appreciation denotes an interactional valuation, often shaped by affective modulation and situated perception. In places where appreciate might be misread as synonymous with anticipate, we have reviewed the phrasing and, where needed, clarified the intended evaluative meaning to avoid ambiguity.

[25] It is important to distinguish between failure and threat. In our framework, failure refers to a breakdown in interactive continuity — the system's inability to continue its current trajectory based on available anticipations. Threat, by contrast, is an affective construal of such breakdowns. It arises when a failure (or the anticipation of failure) is evaluated in light of the system's goals, values, or identity. Not all failures produce threat, and not all threats correspond to actual failures. Threat only emerges when breakdown is reflectively interpreted as a significant risk to systemic coherence, goal success, or agency.

[26] In this framework, "value-rich" does not refer to static or predefined values, but to graded affective-evaluative modulations that guide ideational differentiation. These anticipative constructs do not signal binary success or failure but instead offer continuous, nuanced feedback about how well ongoing trajectories align with the system's internal goals, emerging coherence, or learning potential. They allow the system to adapt even in ambiguous or transitional states, where failure has not occurred, but full resolution has not yet been achieved.