A general motivational architecture for human and animal personality

Marco Del Giudice [*]

University of New Mexico, USA

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ABSTRACT

To achieve integration in the study of personality, researchers need to model the motivational processes that give rise to stable individual differences in behavior, cognition, and emotion. The missing link in current approaches is a *motivational architecture*—a description of the core set of mechanisms that underlie motivation, plus a functional account of their operating logic and inter-relations. This paper presents the initial version of such an architecture, the *General Architecture of Motivation* (GAM). The GAM offers a common language for individual differences in humans and other animals, and a conceptual toolkit for building species-specific models of personality. The paper describes the main components of the GAM and their interplay, and examines the contribution of these components to the emergence of individual differences. The final section discusses how the GAM can be used to construct explicit functional models of personality, and presents a roadmap for future research.

The field of personality is experiencing a renewed drive toward conceptual integration. This is exemplified by landmark contributions such as the position paper by Baumert and colleagues (2017) and the recent volume on personality dynamics and processes edited by Rauthmann (2021). After decades of intense but often narrow focus on the descriptive structure of personality, researchers aspire to reconcile structure with process, integrate between- and within-person mechanisms of variation, move beyond factor-analytic models, and—most crucially—rebuild the theory of personality on solid functional grounds (Baumert et al., 2017; Beck and Jackson, 2020, 2021; Blum et al., 2021; Cervone, 2021; Lukaszewski, 2021; Revelle and Wilt, 2021; Zeigler-Hill et al., 2019).

The project to renovate the science of personality is increasingly converging on two related principles. The first is what I call the *mechanistic principle:* the idea that to understand how personality works we need to model the interacting psychological mechanisms that give rise to stable individual differences in patterns of behavior, cognition, and emotion. This principle traces back to the Allportian definition of personality as "the dynamic organization within the individual of those psychophysical systems that determine his unique adjustments to his environment" (Allport, 1937). Today, evolutionary psychology offers new and powerful tools to identify evolved psychological mechanisms and uncover their computational logic, enabling the reconstruction of personality via "ground-up adaptationism" (Lukaszewski, 2021; Lukaszewski et al., 2020).

The second principle I label the *motivational principle*. This is the notion that, at a fundamental level, the patterns of individual differences that we call "personality" arise from differences in the functioning of motivational processes—and, by implication, the affective processes that turn threats and opportunities, successes and failures into a rich and vibrant tapestry of emotions. This principle also has deep roots in the history of personality research (e.g., Cattell, 1957; Murray, 1938), and is expressed in the idea that personality traits reflect differences in "motivational reaction norms", or patterns of response sensitivity to specific categories of evolutionarily relevant stimuli and situational cues (Denissen and Penke, 2008). Other influential approaches that give center stage to motivational processes are the Reinforcement Sensitivity Theory of personality (RST; Corr, 2008; Gray and McNaughton, 2000); the affective neuroscience model of personality proposed by Davis and Panksepp (2011, 2018); and computational accounts of personality dynamics such as the neural network models by Read et al., (2010, 2017, 2021) and the Cues-Tendency-Action (CTA) model by Revelle and Condon (2015), whose recent incarnations are heavily influenced by RST (e.g., Brown and Revelle, 2021; Read et al., 2018). However, as I discuss in more detail below, all these approaches rely on unsystematic and/or severely restricted accounts of motivation; even if they yield many useful insights, they cannot support the full weight of a realistic theory of personality.

The confluence of the mechanistic and motivational principle suggests that the missing link in current approaches is a *motivational architecture:* not a full-fledged cognitive architecture (with components for memory, reasoning, action selection, etc.; Sun, 2004; Taatgen and

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Anderson, 2010), but a description of the core set of mechanisms that underlie motivation, plus a functional account of their operating logic and inter-relations. In other words, a motivational architecture is a subset of a cognitive architecture specifically designed to account for the phenomena of motivation (and hence personality). To be heuristically productive, such an architecture must strike the right balance between abstraction and precision, with enough realism to ground a satisfactory model of individual differences but without excessive mechanistic detail.

A cognitive or motivational architecture can be tailored to a particular species, or attempt to capture general features of psychological functioning shared by many kinds of organisms. If the objective is to foster integration between human and animal personality research, the field will benefit the most by starting from a *general* architecture—an abstract and minimalist framework able to fit the specific motivational structures (and cognitive capabilities) of a broad range of animal species in addition to humans. While an architecture of this kind does not immediately translate into usable models of personality, it offers a common language for researchers who study individual differences in humans and other animals, and a conceptual toolkit for constructing detailed, species-specific personality models as the necessary data become available. These are invaluable benefits that would greatly reduce the amount of conceptual and terminological confusion in the discipline; they would also make it possible to go beyond factor-analytic descriptions (see Vonk and Eaton, 2018; Whitham and Washburn, 2017), and start comparing species based on functional similarities and differences.

1. The present paper

In this paper I outline the initial version of the *General Architecture of Motivation* or GAM, and discuss how it can inform future research on human and animal personality. This architecture is built around the *extended coordination approach* to motivation and emotion (Del Giudice, 2022), a recent update of the coordination approach that guides much research on emotions in evolutionary psychology (see Al-Shawaf et al., 2016; Nesse, 1990; Tooby and Cosmides, 1990, 2008). As I discuss in detail below, the extended coordination approach relies on the concept of *motivational systems*—evolved mechanisms that orient behavior toward key biological goals (e.g., physical safety, social status, affiliation, mating) by orchestrating the activation and termination of specific emotion programs. The GAM integrates motivational systems with two other crucial components: a general-purpose system for the pursuit of instrumental goals (goals that ultimately guide the formation of practical action sequences); and downstream behavioral mechanisms that regulate broad directional tendencies toward approach and avoidance (i.e., impulses to "go toward" vs. "go away from" a stimulus; Harmon-Jones et al., 2013). As a result, the GAM can naturally account for individual differences in behavioral persistence and constraint, which are the functional basis for traits like impulsivity and conscientiousness.

The abstract components of the GAM can be realized at different levels of cognitive complexity; the architecture aims to be flexible enough to accommodate the motivational functioning of most vertebrate species. Because my primary field is human psychology, many of the examples and illustrations I provide are centered on our species (especially when dealing with particular motivational systems or emotions). However, it is important to keep in mind that the human version of the GAM is only one of the possible species-specific implementations of a generic architecture. As can be expected, and particularly at this initial stage of development, the GAM contains a number of plausible but speculative assumptions. This is no different from any other account of motivation in the literature; however, it can be useful to stress that the GAM is explicitly intended as a heuristic framework, continuously open to updates, integrations and revisions.

As I present the GAM throughout the paper, I compare and contrast it with a selection of other contemporary models of motivation. These comparisons help situate the new architecture in the broader literature and explain certain key decisions and assumptions. The models I have already cited are Reinforcement Sensitivity Theory, the CTA model, Read and colleagues' neural network models, and Davis and Panksepp's affective neuroscience model. In addition, I discuss the CLARION cognitive architecture (Sun, 2009, 2018; Sun and Wilson, 2014) and the Adapted Heuristics and Architecture (AHA; Budaev et al., 2018, 2019)—two sophisticated computational frameworks that have largely escaped the attention of personality theorists. While the CLARION comes from the human-centered tradition of cognitive science, the AHA is rooted in evolutionary biology and animal behavior, and is explicitly designed to accommodate the motivational functioning of a wide variety of species. With the exception of the AHA, all these models have been used to explain individual differences in personality and/or derive alternative personality taxonomies. I cannot present these models in any detail for reasons of space, so I write as if readers already have some familiarity with them.

Before continuing, note that throughout this paper I use the words "emotion", "affect", and "feeling" more or less interchangeably, without any assumptions about the presence (or absence) of subjective and/or conscious experiences. The question of whether conscious affective processing occurs in at least some nonhuman animals is far from settled (see Budaev et al., 2020; Paul et al., 2020); the GAM is deliberately agnostic in this regard, in order to remain valid across a broad range of species besides humans. Finally, note that the architecture is described at an abstract functional level, and is not intended as a neurobiological model of motivation. Questions about the neural implementation of the mechanisms discussed here (and about cross-species differences in neurobiology) are important and useful in their own respect, but beyond the scope of this paper.

2. The general architecture of motivation: an overview

The overall structure of the GAM is schematically depicted in Fig. 1. The architecture comprises five classes of psychological mechanisms (represented as boxes) and their input/output relations (arrows). The existence of additional perceptual/attentional/cognitive mechanisms (including executive and metacognitive processes when applicable), mechanisms for action selection and motor control, and physiological systems (autonomic system, immune system, etc.) is assumed, but their exact nature and functioning is left unspecified. In this section, I begin with a bird's eye overview of the components of the architecture and their main interactions. The aim is to show the big picture first, and give the reader a general sense of the architecture's logic; by necessity, this overview does not provide a fine-grained account of how the various components work, or in-depth justification of the underlying assumptions. The next section examines each component in more detail, present important theoretical background, and discusses how individual differences in motivational functioning—the building blocks of personality—can be conceptualized and modeled within the framework of the GAM.

At the heart of the GAM are two distinct but interacting "engines" of motivation, which together give direction and purpose to the organism's behavior. The first engine is a collection of motivational systems that set the organism's core biological goals, such as physical safety, mating, and offspring care. The exact number and nature of these systems—as well as their relations of reciprocal activation/inhibition—are going to vary systematically across species. The second engine is the *instrumental goal pursuit system* (IGPS), an open-ended system that manages the pursuit of narrower, more specific goals in the organism's moment-to-moment life. Unlike motivational systems, the IGPS does not have pre-specified goals; what it does is keep and manage a list of *active goals* (i.e., the goals that may be actively pursued and tracked at the moment), direct the production of appropriate actions in the service of those goals, and monitor the organism's success/failure. At any given moment, the IGPS pursues a multiplicity of goals, defined at various levels of concreteness and
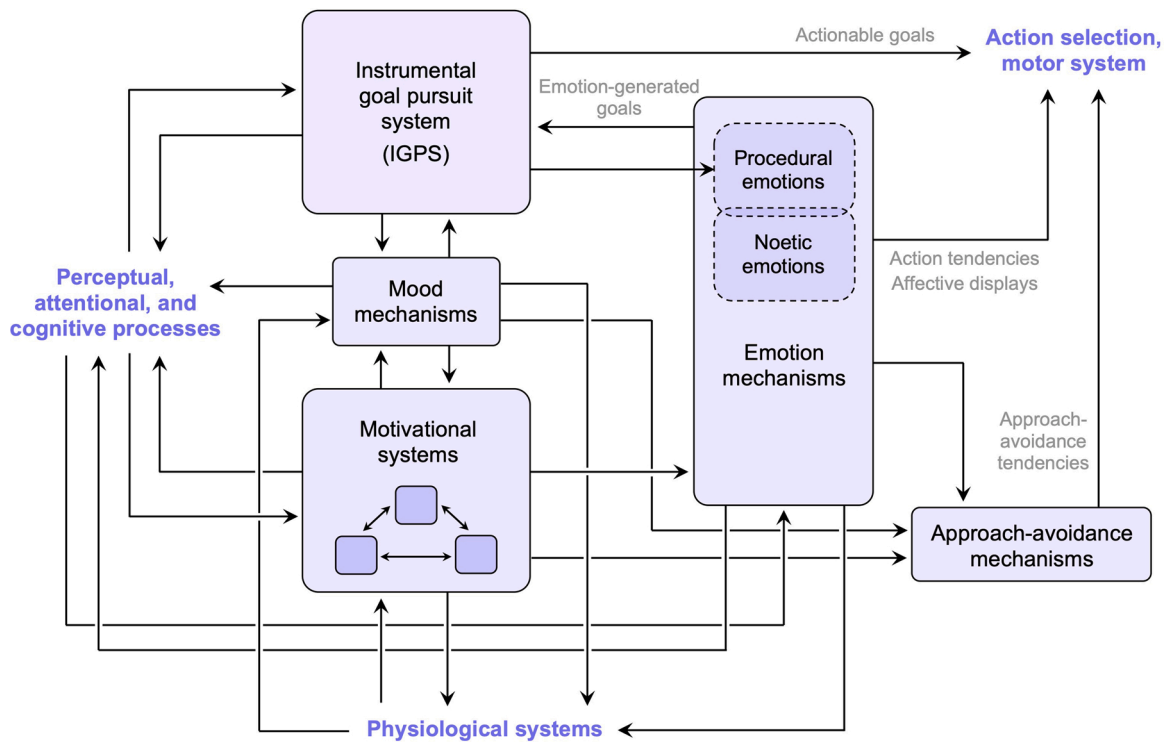
Fig. 1. Schematic diagram of the General Architecture of Motivation (GAM).

specificity (as in "get some food" vs. "catch a fish") and arranged in hierarchical representational structures.

The goals of motivational systems are closely linked to the organism's biological fitness; they act as ultimate sources of value that are motivating in and by themselves. Like hunger and thirst, evolved goals such as survival, physical safety, social belonging and status, mating, and caring for offspring are pursued for their intrinsic rewarding value and not as means to other, more fundamental ends. In this sense, they work as the "prime movers" of all of the organism's actions, plans, and pursuits. Importantly, these goals do not have to be explicitly represented at a cognitive level; instead, they can be represented implicitly, or simply embedded in the evolved algorithms of the various motivational systems and their activating/deactivating cues. (An animal does not need a cognitive representation of its energetic balance to seek out food when hungry and stop eating when sated.).

In contrast, the goals of the IGPS consist of value-laden representations that are potentially accessible to other cognitive systems. The IGPS works as a general-purpose control system that receives its current goals from motivational systems (indirectly through the activation of emotions) and other mechanisms (e.g., executive processes involved in planning). In social species and most notably humans, some of the individual's active goals may be set by other conspecifics (in the form of commands, orders, shared plans, etc.). These goals have an "instrumental" quality in that they are not sources of ultimate value, but more or less indirect means to other ends; they make it possible for the organism to pursue its core biological goals through the complexity of the real world.

Motivational systems and the IGPS receive inputs from perceptual processes (themselves oriented and filtered by attention), but also from other cognitive processes in the form of memories, predictions, results of internal simulations, and so forth. In particular, executive processes related to planning and self-regulation contribute to setting the active goals of the IGPS and resolving complex motivational conflicts (more on this below). On the output side, both motivational systems and the IGPS coordinate the activation/deactivation of emotional mechanisms; but whereas motivational systems activate a wide range of emotions

(including "classic" emotions such as fear, anger, shame, etc., and their domain-specific variants), the activity of the IGPS is associated with a subset of *procedural emotions* that regulate goal pursuit across domains—emotions such as frustration, satisfaction, disappointment, boredom, feelings of rightness/wrongness about the outcomes of one's actions, and anxious indecision in the presence of unresolved conflicts between goals.

The distinction between core biological goals (managed by motivational systems) and instrumental goals (managed by the IGPS) captures a fundamental duality of motivation that has been recognized many times in the literature (e.g., Elliot, 2006). A notable example is the distinction between implicit "motives" and explicit, hierarchically organized "goals" in the research tradition rooted in McClelland's classic work (McClelland, 1987; see Schultheiss, 2021). More recently, the cognitive-motivational theory of emotions proposed by Miceli and Castelfranchi (2015) distinguishes between "goals proper" that involve cognitive representations of the desired outcomes, and "pseudo-goals" that denote the evolved but unrepresented functions of psychological mechanisms (analogous to the "free-floating rationales" of mechanisms designed by natural selection; see Dennett, 2009). Miceli and Castelfranchi perceptively noted that certain kinds of goals proper (framed as "wishes" and "desires") can be actively represented and tracked without being pursued in actual behavior, either because conditions are unfavorable or because the outcomes are (currently) outside of the individual's control.

In line with the GAM, the motivational component of the CLARION architecture comprises two distinct subsystems: a *goal structure* that manages lists of explicit goals, and a collection of *drives* that operate implicitly to promote the satisfaction of both innate and derived needs (Sun, 2009, 2018). Of course, the implicit (or even unrepresented) goals of motivational systems can *also* be represented explicitly by other components of the cognitive system, at least in some species and under some circumstances. If I learn that the purpose of hunger is to control the intake of calories and other nutrients, I can form an explicit representation of this goal and even use it to regulate my feeding behavior. However, the inner workings of the feeding/hunger system remain just

as encapsulated as before, and the system continues to rely on the same evolved cues (blood sugar levels, flavors correlated with the presence of different nutrients…) without regard for the new representational knowledge.

A crucial function of the IGPS is to identify specific, immediate goals with the highest priority within the current goal structure (I label them *actionable goals* for clarity) and pass them along to action selection mechanisms. These mechanisms select the best available actions (based on criteria of feasibility, effectiveness, and efficiency) and turn them into detailed behavioral sequences and motor commands. The precise means of action selection are not specified by the GAM; depending on context (e.g., novel vs. familiar situations) and the organism's cognitive repertoire, it may involve innate fixed action patterns, automated habits, active search through a space of possible actions, or a combination of these and other options.

Actionable goals from the IGPS are the main behavioral output of the entire motivational architecture. In contrast, motivational systems do not *directly* produce actionable goals; they affect the organism's behavior only indirectly, mainly by activating emotion mechanisms (e. g., fear). Emotion mechanisms may then (a) provide the IGPS with urgent but abstract goals (e.g., protecting oneself from danger in the case of fear) that can be integrated in the current goal structure and eventually translated into actionable goals; (b) prompt the termination or suspension of currently active goals (e.g., stop protecting oneself in the case of relief); (c) trigger emotion-specific action tendencies (e.g., an impulse to run away or hide), and/or affective displays such as facial and vocal expressions; and (d) modulate the activity of *approach-avoidance mechanisms* to produce directional tendencies in relation to salient stimuli (e.g., avoidance of danger, approach to safety; see McNaughton et al., 2016). Approach-avoidance tendencies are more generic that emotion-specific action tendencies: they prompt the organism to go toward or away from a stimulus, but do not prepare it for particular actions such as running away, expelling, attacking, hugging, and so forth.

Simplifying a bit, the interplay between motivational systems and the IGPS can be understood in terms of two partially nested control loops linked by emotions. Motivational systems constitute the outer loop, constantly evaluating the current situation in light of the organism's core biological goals and activating the relevant emotions. The emotions triggered by motivational systems provide situation-specific goals to the IGPS, which integrates those goals in the current structure and attempts to fulfill them (by turning them into actionable goals and monitoring their success or failure), thus closing the inner loop. This simple but powerful theoretical device joins the two sides of motivation into a unified, mechanistically plausible account in which emotions bridge the gap between qualitatively different kinds of goals.

As they carry out their functions, motivational systems and the IGPS collect a steady stream of information about the organism's successes and failures in pursuit of specific goals. This information is fed to superordinate *mood mechanisms*, where it is integrated with other inputs about the state of the organism (e.g., its immunological condition, energetic balance, and level of fatigue), and used to compute summary estimates of the momentum of current efforts, the overall propitiousness of the environment, and the organism's future prospects. Based on these estimates, mood mechanisms strategically modulate the activity of multiple motivational systems and the IGPS, bringing about the persistent motivational-affective states that we call "moods." If emotions are coordination programs that adaptively orchestrate the activity of other psychological and physiological mechanisms (Tooby and Cosmides, 1990), motivational systems and the IGPS can be understood as *second-order* coordination mechanisms; in the same vein, mood mechanisms provide a *third-order* layer of coordination to the system (Del Giudice, 2022).

The higher-order coordination function of moods can be contrasted with the role of approach-avoidance mechanisms in the GAM. In this architecture, approach and avoidance are not superordinate motives (or categories of motives), but downstream "effectors" that can be activated

by a host of other mechanisms higher in the control hierarchy—namely emotions, motivational systems, and moods. In other words, they represent a shared output pathway for a multitude of domain-specific goal-directed systems.

3. Components of the GAM and sources of individual differences

3.1. Motivational systems, emotions, and moods

3.1.1. Emotions as coordination programs

According to the coordination approach, emotions can be understood as organismic modes of operation or "programs" that evolved to solve the *coordination problem*—the adaptive problem of how to orchestrate large suites of cognitive, physiological, and behavioral mechanisms so as to produce efficient but flexible responses to recurrent fitness-relevant situations (Al-Shawaf et al., 2016; Nesse, 1990; Tooby and Cosmides, 1990, 2008). Emotions thus conceptualized include states that are not usually labeled as emotions, for example hunger and sexual arousal. Importantly, evolved emotion mechanisms do not necessarily correspond in a one-to-one fashion to folk categories such as "anger" or "anxiety"; a given word may actually refer to multiple underlying mechanisms, each specialized to deal with a specific kind of situation (e. g., anger triggered by agonistic challenges vs. anger triggered by separation from a caregiver; see Scarantino, 2012; Sznycer et al., 2017). In line with their organism-wide coordination function, emotions modulate a wide range of downstream processes that include perception, attention, memory, reasoning and inference, categorization, and learning; they also generate goals and priorities, action tendencies, affective displays, and physiological reactions (see Tooby and Cosmides, 1990, 2008). The multiple outputs of emotion mechanisms are represented in Fig. 1 as arrows pointing to other components of the architecture.

In the standard coordination approach, emotion mechanisms include *situation-detecting algorithms* in addition to coordination programs, so that each emotion works as a self-contained "module" that appraises the state of the world and deploys the appropriate response when triggered. However, the existence of a large number of specialized emotions gives rise to a second-order coordination problem (how to coordinate the coordinators); moreover, the meaning of a situation at a given point in time often depends critically on the preceding sequence of situations (consider for example revenge, betrayal, or reconciliation), raising additional difficulties for the appraisal process (the *sequence integration problem*). As a solution to these problems, I proposed to extend the coordination approach with a layer of motivational systems that effectively work as second-order coordination mechanisms (Del Giudice, 2022).

3.1.2. Motivational systems

The concept of motivational systems (or *behavioral systems*) originates in the instinct theories of the early 20th century (e.g., McDougall, 1908). It was formalized by ethologists between the 1950 s and the 1970 s (e.g., Baerends, 1976; Tinbergen, 1951), and brought back into the psychological mainstream with the work of Bowlby (1982) and others (for an extended history of this construct see Del Giudice, 2022). In brief, motivational systems can be understood as evolved control mechanisms devoted to the pursuit of core biological goals. Emotions arise in relation to the activation of a motivational system (which may be triggered by threats or opportunities), the progress of current behavior in relation to the system's goal, and the consequences of behavior (success vs. failure). For example, the *attachment system* in infants and children has the set goal of maintaining the proximity and/or availability of the caregiver (and the ultimate function of ensuring the child's survival in a dangerous world). The system is activated by perceived dangers or separations (with feelings of separation anxiety, distress, loneliness), and successfully deactivated by the attainment of proximity and protection (with feelings of relief, comfort,

and "felt security"). Lack of progress in reaching proximity can elicit anger and protest behaviors (e.g., crying, yelling), whereas protracted failure of the system leads to sadness and despair. While the preceding summary is tailored to attachment in human infants, attachment processes and the functioning of the attachment system have also been studied in other primates and mammals (Davis and Panksepp, 2018; Feldman, 2016; Maestripieri, 2003; Panksepp, 1998; Suomi, 2016).

As just described, a motivational system can embody a set of thematically related goals rather than a single overarching goal. For instance, the goals of a system that regulates status/dominance relations may include improving, maintaining, and displaying one's status, as well as deferring or submitting to higher-status individuals (e.g., Gilbert, 2005). Motivational systems may embody sophisticated and context-sensitive operation rules, that respond flexibly to the state of the environment and draw on internal representations and "working models" of the world (e.g., inferences about the caregiver's intentions, expectations about the caregiver's likely response, representations of the child's value to the caregiver). The representations that regulate the functioning of motivational systems are constructed from repeated interactions with motivationally relevant situations (e.g., experiences of separation, reunion, and protection or lack thereof), and typically operate at an implicit level, in line with the concept of *internal regulatory variables* invoked by evolutionary theories of motivation (Tooby et al., 2008). Among other possibilities, correlations between the operating parameters (e.g., activation thresholds) of two or more motivational systems can arise if those systems rely on shared representations and/or regulatory variables; for example, representations of an individual's own strength and formidability may simultaneously influence motivational functioning in the domains of dominance, mating, attachment, and so forth.

Classical ethological theory emphasized feedback as the operating principle of motivational systems. A virtually exclusive focus on feedback control is still found in many current theories of self-regulation (e.g., Carver and Scheier, 2013, 2014; DeYoung, 2015; DeYoung and Krueger, 2018) and formal models of motivation—including the CTA model (Revelle and Condon, 2015) and the neural network models by Read and colleagues (Read et al., 2010, 2017). However, the existence of internal working models expand the range of possibilities by enabling both feedback and *feedforward* control: by representing future events and the likely outcomes of one's behaviors (even in a highly simplified format), motivational systems can produce anticipatory responses, without the need for constant course correction that characterizes purely feedback-regulated systems (Del Giudice, 2022; for more on the relative strengths/weaknesses of feedback and feedforward control and how the two are integrated in biological systems, see Del Giudice, 2015; Del Giudice et al., 2018).

In the extended coordination approach, motivational systems perform most of the appraisal tasks that were previously attributed to emotions: they contain situation-detecting algorithms that control the system's activation, as well as *goal pursuit/evaluation algorithms* that monitor the progress of current behavior in relation to the active goals, evaluate situations in terms of success vs. failure, and deploy the appropriate emotions. Crucially, a given motivational system is not tied to a single emotion, but to a *set* of characteristic emotions (which can be "positive" as well as "negative"). Different emotions are activated depending on contextual factors, internal representations, and the moment-to-moment consequences of the individual's actions. Also, emotions may be shared by more than one system: for example, anger——or, quite possibly, alternative domain-specific variants of the "anger" program—can be triggered in the context of attachment, but also in those of status competition, aggressive defense, pair bonding, or reciprocal exchange. These one-to-many relations between motivations and emotions distinguishes the extended coordination approach (and hence the GAM) from Panksepp's theory of "basic emotional systems" (Panksepp, 1998, 2005, 2011; Davis and Panksepp, 2018). Panksepp postulated the existence of specialized affective/motivational mechanisms

such as RAGE, CARE, and PLAY, but linked each system to one and only one "primary emotion" or "core emotional feeling" (e.g., anger for RAGE, joy for PLAY). This narrow focus on single emotions precludes the strategic flexibility and computational richness of multi-emotion motivational systems.

3.1.3. Coordination of motivational systems

Any given situation or event may be potentially relevant to several distinct biological goals, prompting the question of how multiple motivational systems can achieve coordination and resolve conflicts between competing motivations. The first answer is that motivational systems directly modulate each other's activity, resulting in patterns of reciprocal potentiation and inhibition (bidirectional arrows in Fig. 1). For example, when the attachment system becomes activated it quickly suppresses play and curiosity-driven exploration (Bowlby, 1982). Other important data on the reciprocal relations between motivations come from Panksepp and colleagues' research program; to illustrate, Panksepp (1998) presented evidence that activated RAGE inhibits the activity of FEAR, PANIC, and SEEKING, whereas FEAR potentiates the other three systems. Reciprocal inhibition between motivational systems is also a key feature of the CTA model (Revelle and Condon, 2015; note that, in principle, the model also permits reciprocal potentiation, even if this possibility has not been emphasized). In the CLARION, drives do not directly affect one another, but compete and cooperate at the level of metacognitive processes (which perform goal-setting based on inputs from drives; Sun, 2009, 2018). The Adapted Heuristics and Architecture employs a mechanism whereby alternative motivational systems ("survival circuits") compete to determine the *global organismic state* of the individual (GOS; LeDoux, 2012); the circuit that wins the competition becomes the GOS, and a top-down filter suppresses attention to all cues not related to the current GOS (Budaev et al., 2018).[1] Even if it lacks direct forms of reciprocal modulation between motivational systems, the AHA offers an important insight: the emotional responses triggered by active motivations tend to shift the focus of attention toward emotion-relevant information and enhance the corresponding perceptual processes—thus contributing to dampen the activity of the competing systems, even without the intervention of a centralized filter. In line with most other models in this area, the extended coordination approach assumes that multiple motivations are typically active at any given time (and thus can give rise to multiple coexisting emotions), unless one particular system becomes activated with such intensity and urgency that it temporarily overshadows and/or suppresses all other motivations.

While direct and indirect forms of reciprocal modulation can confer self-organization qualities on the architecture, they are probably insufficient to ensure smooth coordination and conflict resolution when there are more than a handful of motivational systems. The result is a third-order coordination problem that could be addressed by an additional, higher-order layer of control mechanisms. The extended coordination approach is unique in that it includes mood mechanisms, which fulfill precisely this role (Del Giudice, 2022). Moods are long-lasting and diffuse; despite their powerful impact on motivation, they usually lack well-defined triggering stimuli, and do not entail specific action tendencies like emotions do (Beedie et al., 2005; Gendolla, 2000). Mood

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[1] Budaev et al. (2019) clarified that, if arousal is low in all the survival circuits, the organism may not enter a strict GOS but continue to pursue multiple needs simultaneously. On a related note, the AHA combines the attentional suppression of competing motivations with a "dynamic threshold" competition algorithm, which makes it easier to switch to a different motivation when the current arousal is high, and harder to switch when arousal is low (Budaev et al., 2018). Dynamic thresholding may be computationally convenient as a means to stabilize the agents' behavior and enable smooth transitions between motivational states; however, it is not based on observations or experimental data and its biological plausibility is unclear.

states seem to reflect integrative estimates about the organism and its environment—variously described as the probability of encountering threats vs. opportunities, the momentum of recent outcomes, the progress (or lack thereof) toward the individual's goals, and the expected success of future actions (e.g., Eldar et al., 2016; Nesse, 2004; Nettle and Bateson, 2012). In the extended coordination approach and the GAM, these (implicit) estimates are computed by superordinate mechanisms, based on information from motivational systems about success and failure in the pursuit of domain-specific goals (together with other inputs that encode the state of the organism, e.g., from the immune system). The same mechanisms strategically modulate the functioning of multiple motivational systems—not just by generically "activating" or "inhibiting" them, but also by selectively influencing their sensitivity to threats vs. opportunities (see Nettle and Bateson, 2012; more on this below).[2]

To sum up, the coordination of motivational systems in the GAM is achieved with three partially redundant strategies: (a) direct reciprocal modulation between motivational systems; (b) indirect reciprocal modulation via emotions, which suppress attention to motivationally incongruent information; and (c) simultaneous modulation of multiple systems by mood programs. Moreover, executive processes—which strictly speaking are not part of the architecture—offer yet other routes for attentional, cognitive, and behavioral regulation, which should be especially useful when dealing with motivational conflicts in complex social situations.

3.1.4. Refinements to the extended coordination approach

The conceptual structure of the extended coordination approach is summarized in Fig. 2. The figure presents a slightly updated, more realistic version of the initial account presented in Del Giudice (2022). The original discussion of the extended coordination approach emphasized the hierarchical arrangement of emotions (first-order coordination), motivational systems (second-order coordination), and moods (third-order coordination). Fig. 2 relaxes this assumption, and underlines that the hierarchy admits two limited but important exceptions. First, certain simple stimuli (which may be called *elementary triggers*) are able to evoke emotional responses in an almost reflex-like fashion. For example, a sudden loud noise directly triggers a fearful response; unexpectedly bumping into something (including an inanimate object) may lead to a flash of angry irritation, disconnected from the usual relational and motivational contexts of anger. A plausible explanation is that at least some emotion mechanisms include "quick and dirty" detectors that can bypass the more sophisticated appraisal machinery of motivational systems. Whether the subsequent responses should be regarded as full-fledged emotions versus "primitive emotions" or "proto-affects" (Ortony et al., 2005) is not critical in this context; the key point is that emotional mechanisms can become activated even without the mediation of motivational systems.

Second, the arrows at the bottom of Fig. 2 imply that both mood mechanisms and motivational systems can directly modulate certain downstream processes without the mediation of lower-level mechanisms; however, they are going to do so in ways that are more generic and less situation-specific. For example, the activation of the attachment system may automatically direct attention toward (or away from) the current location of the caregivers, and trigger categorization processes

that parse the environment in terms of potential threats vs. potential sources of help and comfort. These implicit forms of regulation have been described and researched by human attachment theorists (see Bretherton and Munholland, 2016; Mikulincer and Shaver, 2016; Pietromonaco and Barrett, 2000; Sherman et al., 2015). Likewise, being in an elevated or dejected mood is likely to have some broad, nonspecific effects on attention, approach-avoidance tendencies, and so forth (e.g., a general tendency toward approach and a diffuse, flexible attentional focus when mood is elevated). The refinements to the extended coordination approach described in this section are also included in the diagram of the GAM presented in Fig. 1.

3.1.5. Motivational systems in humans

As I noted earlier, the GAM provides general functional principles for motivational systems, but leaves their exact number and nature unspecified. This is because different species are endowed with somewhat different motivational toolkits, whose content depends on the ecology and phylogeny of each species. This is another point of departure from Panksepp's model, which recognizes emotional systems as "basic" or "primary" only if they are shared across all mammalian species (Davis and Panksepp, 2018). In particular, humans have evolved complex forms of social interaction that make our species unique among mammals and primates; it would be truly surprising if we did *not* to possess some species-specific motivations and emotions, in addition to many specialized variations on pan-mammalian motives (Al-Shawaf et al., 2016; Aunger and Curtis, 2013). Needless to say, this general principle applies (in various degrees) to every animal species, not just to humans.

To illustrate this point, Fig. 3 shows a partial, admittedly tentative map of human motivational systems (Del Giudice, 2022). Setting aside basic physiological needs like hunger, thirst, and thermoregulation (which lie outside the scope of present-day models of personality), human motivations can be parsed into five broad categories of adaptive problems: (a) prevention and avoidance of physical hazards; (b) acquisition and enhancement of resources (including "embodied" resources such as knowledge and skills); (c) mating and reproduction; (d) relations with kin; and (e) relations within and between groups. Each of these categories comprises several specific problems, which in turn give rise to the biological goals pursued by motivational systems.

The map in Fig. 3 is derived from recent syntheses of the evolutionary literature on motivation (Aunger and Curtis, 2013; Del Giudice, 2018; Kenrick et al., 2010); it comprises systems for *aggression*, *fear*, *precaution* (prevention of potential threats), *disgust*, *status*, *affiliation*, *reciprocity*, *mating*, *pair bonding*, *attachment*, *caregiving*, *acquisition*, *curiosity* (including exploration)*, play*, and—more provisionally—*predation* and *creation*. While some of these systems are associated with a single emotion (as in the case of disgust), others control a variety of positive and negative emotions (for example, status competition can evoke pride, confidence, shame, anger, etc.). The figure is meant exclusively as an illustration, as there is no room for a thorough presentation of each system. Readers are directed to Del Giudice (2022) for more details, and for a discussion of some of the conceptual and methodological challenges involved in mapping a species' motivational landscape.

3.1.6. Individual differences

Differences in the functioning of motivational systems (and hence in patterns of emotion) are arguably the single most important source of variation in personality. A simple and economical way to describe them is in terms of *activation sensitivity:* a system is more sensitive if it becomes activated more quickly and intensely by the same situational cues. This approach is the one most commonly found in the literature. In Davis and Panksepp's (2018) affective neuroscience model, personality arises from differences in the responsiveness of emotional systems such as CARE and PLAY. The Adapted Heuristics and Architecture formalizes this notion with a set of parameters that modulate the final intensity of each of the animal's motivations (Budaev et al., 2018); likewise, Sun and Wilson (2014) operationalize personality differences in the CLARION
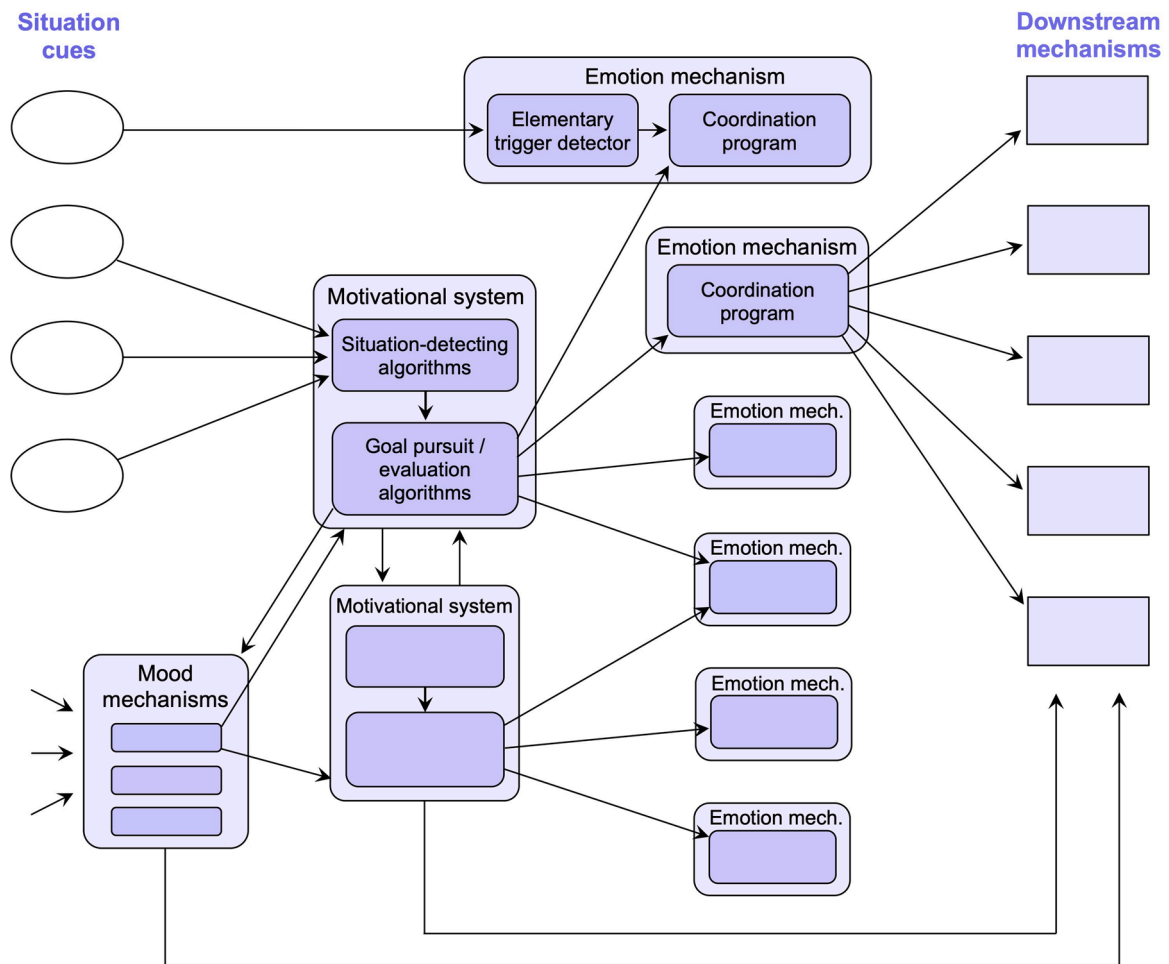
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[2] Note that the need for higher-order coordination decreases as the number of mechanisms to coordinate becomes progressively smaller. Most evolutionary theories of emotions postulate the existence of dozens of specialized programs—too many to effectively self-organize via reciprocal facilitation/inhibition. A smaller set of perhaps 10–20 motivational systems can plausibly get some mileage from reciprocal modulation, while still benefitting from top-down regulation by moods. It is unclear if fourth-order coordination mechanisms above moods would provide additional benefits, and what they would look like in practice (for extended discussion see Del Giudice, 2022).

Fig. 2. Schematic diagram of the extended coordination approach. For visual clarity, the arrows pointing to the downstream mechanisms on the right are shown only for one of the emotion mechanisms. Also, it is implied that the activity of downstream mechanisms will usually affect the current situation, thus feeding back to the situational cues on the left.

Modified with permission from Del Giudice (2022).

architecture by varying the activation sensitivities of implicit drives. The neural network models by Read et al. (2010) adopt a similar but somewhat more complex scheme, which combines specific activation weights for each motive with two overall sensitivity parameters, one for approach motives and one for avoidance motives.

A single parameter may be enough to describe the sensitivity of "unipolar" motivational systems that respond *only* to threats (e.g., disgust) or opportunities (e.g., play). However, many if not most systems are designed to detect both positive and negative situations and respond accordingly: the status system can be activated by opportunities to rise in social hierarchies *and* by challenges to one's current rank; the mating system can be activated by meeting an attractive potential partner *and* by the presence of sexual rivals; the acquisition system is activated by the prospect of acquiring resources *and* by the risk of losing them or having them taken away (for more examples see Del Giudice, 2022). In such cases, it can be useful to use two distinct (if potentially correlated) parameters to distinguish between a system's sensitivity to opportunities and its sensitivity to threats.

Another valuable refinement is to separate activation from *de*activation, and explicitly model individual differences in the sensitivity to cues that tend to disengage the system (e.g., cues of safety and absence of danger in the case of fear; proximity to a caregiver in the case of attachment; copulation or rejection in the case of mating; winning or losing in the case of status competition). In the CTA model, each cue-tendency-action loop—functionally analogous to a bare-bones

motivational system—is controlled by a "stimulation strength" parameter that turns cues into action tendencies; an "excitation" parameter that turns tendencies into actions; and a "consummation" parameter that determines the strength of negative feedback by which actions turn off action tendencies (Revelle and Condon, 2015). In this way, the CTA can model patterns of individual variation in both activation and deactivation sensitivity.

From a complementary perspective, individual differences in the functioning of a motivational system can be analyzed by unpacking the working models and internal regulatory variables that inform that system. This approach is best exemplified by the literature on human attachment styles. Researchers have identified two main dimensions of individual variation—*anxiety* (or *preoccupation*) and *avoidance*—which can be linked to different patterns of (largely implicit) beliefs and expectations about the person's own vulnerability and lovability and the availability and sensitivity of attachment figures (see Bretherton and Munholland, 2016; Fraley and Spieker, 2003; Fraley et al., 2015; Griffin and Bartholomew, 1994; Mikulincer and Shaver, 2016, 2020). Of note, anxiety can be framed as a "hyperactivating" strategy (quick, intense activation in response to perceived threats coupled with slow deactivation) and avoidance as a "deactivating" strategy (characterized by low activation sensitivity); by comparison, attachment security is characterized by quick activation of the system, followed by similarly rapid deactivation upon reassurance (Mikulincer and Shaver, 2016; Mikulincer et al., 2003).
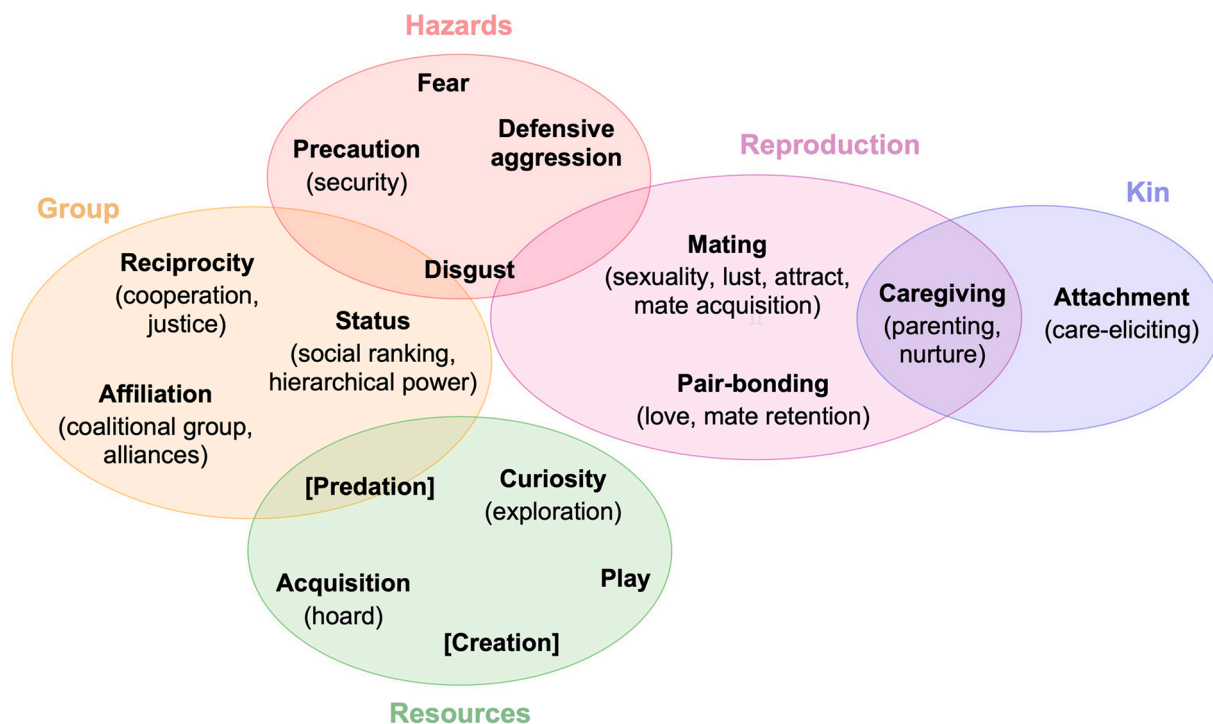
Fig. 3. A partial map of human motivational systems, grouped into five broad categories of adaptive problems. Some alternative labels used in the literature are shown in parentheses. The systems in square brackets are still mostly hypothetical but warrant further investigation. Note that the map does not include basic physiological needs such as hunger/thirst, evacuation, or thermoregulation.
Modified with permission from Del Giudice (2022).

The first take-home point of this example is that describing individual differences in the functioning of a single motivational system—even in a simplified form—may easily require more than one dimension of variation. The second point is that there may be alternative ways to construe and summarize those differences, depending on one's focus on (a) internal working models and/or regulatory variables versus (b) patterns of activation/deactivation sensitivity. Of course, these two levels of analysis are connected, because differences in activation/deactivation sensitivity are going to partly reflect differences in internal models and variables (e.g., a model of one's social standing as precarious and others as hostile and dominant can easily lead to heightened sensitivity to potential cues of status competition, and more intense reactions to perceived challenges).

So far, the notion of describing individual differences in motivation as activation patterns has been pursued most consistently by Shaver, Mikulincer, and colleagues. These authors have described "hyper-activating" and "deactivating" strategies—modeled on anxious and avoidant attachment styles—for a variety of other systems such as exploration, caregiving, sexuality, and power (i.e., status), and developed questionnaire scales to measure them dimensionally (see Mikulincer and Shaver, 2020). While this is a promising approach in some respects, its limitations must be pointed out. The main problem is that what works for attachment may not adequately capture the unique logic of other motivational systems. To illustrate, Shaver et al. (2011) assume that submissiveness and self-abasement reflect a "deactivating" strategy of the power system, when they are better understood as a specific response modality directed toward subordination (Gilbert, 2005, 2006). The point is that attachment and hierarchical relationships have radically different functions and dynamics; to give just one example, avoiding displays of distress and neediness by limiting the activation of the attachment system may help maintain a modicum of closeness to a rejecting caregiver; but failing to respond to challenges and provocations will do little to appease a rival for status (and may actually be construed as defiance). More generally, a simple

hyperactivation/deactivation dichotomy necessarily fails to capture differential sensitivities to threats vs. opportunities; and even in unipolar systems like fear and disgust, activation and deactivation sensitivities may not covary precisely as they do in the context of attachment.[3] I expect that researchers will often need more than just a couple of parameters (or dimensions) to adequately describe individual differences in a given motivational system. In any event, there are no alternatives to a careful analysis of each system, the adaptive problems it is designed to solve, and the specific challenges and rewards that characterize different social and ecological domains (see Del Giudice, 2022).

Shifting to a higher level of analysis, individual differences in motivational parameters are going to be functionally patterned not only within, but also *between* systems. As noted earlier, if two or more systems rely on shared internal variables one can expect their operating parameters to be correlated across individuals; multiple systems may also be affected by the same environmental inputs, hormonal signals (e.g., sex hormones), and other causal factors. It then becomes possible to identify higher-order dimensions of variation that summarize broad patterns of functioning across motivational domains. Plausible examples of such dimensions include generalized sensitivity to threats (arising from positive correlations among threat-related activation sensitivities) and generalized sensitivity to opportunities (same with respect to opportunity-related sensitivities). Taken together, these generalized sensitivity traits would contribute to explain individual differences in risk sensitivity (e.g., the combination of high sensitivity to opportunities and low sensitivity to threats can be expected to increase risk-taking). Other examples of higher-order traits are the dimension of

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[3] The assumption that attachment is a unipolar system that is only activated by threats is pervasive in attachment research, but debatable. It neglects the fact that, in order to form attachment relationships, humans and other animals must be predisposed to detect *opportunities* for forming them, e.g., the presence of a protective other who shows caring and affection.

motivational masculinity-femininity (i.e., coordinated variation in parameters that differ systematically between males and females), and the motivational correlates of the fast-slow continuum of life history strategies (see Dammhahn et al., 2018; Del Giudice, 2020; Del Giudice et al., 2015).

Another source of cross-domain variation is the tendency to experience certain mood states rather than others, given that the main function of moods is to coordinate the activity of multiple motivational systems at once. In principle, individual differences in mood can arise from differences in the activation sensitivity of mood mechanisms, differences in the "inertia" of mood programs once they are initiated, or differences in the functioning of motivational systems which provide the inputs for mood-related computations. Empirically, these scenarios may be hard to differentiate from one another and from more complex patterns of reciprocal interaction. To complicate things further, our present understanding of moods from a functional and computational standpoint is quite limited; even the most promising models (e.g., Nettle and Bateson, 2012) remain exceedingly abstract, and we still lack a refined taxonomy of mood states beyond generalities such as "positive", "anxious", or "depressed".

Finally, one may consider the possibility that there are meaningful individual differences in the strength—or even the sign—of the modulatory effects that motivational systems exert on one another. Although some formal models of motivation can easily incorporate variation in patterns of between-system modulation (e.g., the CTA model via its "inhibition" parameters), empirical research on this topic is virtually nonexistent. Intriguingly, differences in the strength of inhibitory effects across systems can be expected to yield differences in the persistence (vs. volatility) of motivational states over time, with stronger reciprocal inhibition corresponding to increased motivational persistence. In their personality simulations, Read et al. (2010) leveraged this effect to reproduce a general dimension of disinhibition vs. constraint (closely related to impulsivity and conscientiousness). However, it is not clear that the tendency to become "locked" into a particular motivational frame—and hence unresponsive to other features of the situation—is enough to capture the full meaning of constraint, which has a lot to do with the prioritization and maintenance of instrumental goals in the face of all sorts of motivational "pulls". As I discuss below, the GAM offers a more natural way to conceptualize these aspects of motivation and personality as parametric variation in the functioning of the IGPS.

3.2. The instrumental goal pursuit system and the concept of procedural emotions

Motivational systems equip organisms with basic evolved goals to strive for, and actively shape behavior through emotions; however, a complete account of motivation cannot stop here. Throughout their life, animals pursue all kinds of practical goals—most of which are only very indirect linked to core motivations like attachment and mating, or stem from the need to carry out routine activities, deal with unexpected events and disturbances, coordinate with other individuals, and—at least in the case of humans—fulfill obligations and duties, obey commands, follow norms and instructions, and so forth.

In the GAM, goals of this kind are called "instrumental" to distinguish them from their ultimate-value counterparts implemented by motivational systems; however, this does not imply that they appear secondary or derivative when viewed from the perspective of the individual. In fact, instrumental goals are the *only* goals in the architecture that are cognitively penetrable, and thus directly accessible to conscious awareness (at least in humans, and possibly other species as well). Naturally, people can become *indirectly* aware of the goals of motivational systems via self-observation, reflection, or learning. Still, those goals are not directly accessible in the same way of active IGPS goals. After touching a disgusting object, one can have the conscious intention to wash one's hands clean; in the GAM, this is an actionable instrumental goal derived by the IGPS from the more abstract goal "clean myself"

generated by the emotion of disgust. However, the underlying biological goal of the disgust system—preventing contamination by pathogens and toxins—is not available to introspection; in all likelihood, it is best understood as a "free-floating rationale" that is not even represented by the system itself.

As a rule, reaching complex instrumental goals like "build a nest" requires completing sequences of shorter-term subgoals ("find some straws", "arrange the straws", etc.), which in turn may be further decomposable into smaller and more immediate tasks. The standard assumption in the cognitive science literature is that goals and sub-goals are represented and pursued in a hierarchical fashion; at the same time, there is a long-standing debate that pits rigid, "stacked" goal hierarchies against looser representations that admit at least some amount of parallel processing (see e.g., Anderson, 1983; Bryson, 2000; Simon, 1967; Sun, 2004; Taatgen and Anderson, 2010; Tyrrell, 1993; Uusberg et al., 2019). In this context, the GAM only makes the mild assumption that instrumental goal representations are at least loosely hierarchical. In our species, hierarchies of goals can become quite deep and layered (Schultheiss, 2021); the overarching goals at the top of those hierarchies (e.g., "become a surgeon") may be located far away in the future, and be pursued—albeit intermittently—for years or even decades.

3.2.1. The IGPS as a general-purpose control system

In the GAM, instrumental goals are managed by a specific mechanism—the IGPS. The IGPS maintains a list of active goals and subgoals; determines priorities between competing goals; derives actionable goals that can be passed along to action selection systems; and monitors progress, success and failure in relation to active goals. As noted earlier, actionable goals from the IGPS are the main behavioral output of the motivational architecture (complemented by action tendencies, affective displays, and approach-avoidance tendencies; see Fig. 1). Obviously, the IGPS is a stand-in for a collection of diverse and potentially quite complex cognitive processes (which may involve access to multiple valuation systems, internal simulations, working memory, etc.). The GAM packages these processes into a single abstract mechanism, without specifying the precise algorithms by which it performs its tasks. The purpose of the IGPS within the GAM is not to provide a mechanistically precise account of goal management, but to capture some of its essential features, in a way that can usefully inform models of individual differences.

In this spirit, this section adds some detail to the basic sketch of the IGPS presented so far. The IGPS works like a general-purpose, "programmable" control system that maintains a list of active goals, arranged in hierarchical fashion and represented at various levels of specificity. Typically, goals that are more abstract and/or higher in the relevant hierarchy tend to be located farther away in the future. Also, goal representations are value-laden, and the positive or negative value associated with each goal is used by the IGPS to determine that goal's priority in the control of behavior. The IGPS also translates abstract goals into appropriate sub-goals (depending on the current context, the options available to the individual, etc.), and attempts to find lower-level goals that will contribute to advance multiple higher-level goals at once, or at least achieve a compromise between contrasting goals (see also Sun, 2009). Immediate goals with the highest priority become "actionable" and are passed along to action selection mechanisms, where they are turned into behavioral sequences and motor commands. Finally, the IGPS monitors the current level of progress toward the active goals, determines success/failure, and revises the goal structure accordingly (e.g., by removing goals that have been successfully achieved or have gotten beyond reach).

While the GAM does not explicitly include executive/metacognitive mechanisms as a component of the architecture, certain functions of the IGPS clearly grade into executive territory. From the perspective of the GAM, goal management takes place on a continuum of automaticity: most routine decisions about the goal structure (including conflicts among competing goals) can be managed by relatively simple and

automatic algorithms, but more complex scenarios—particularly those involving relationship dynamics in species with intricate social structures like humans—may require the intervention of deliberate top-down control processes. There is substantial evidence that forms of executive control are widespread in nonhuman species; likewise, many animals seem to employ certain kinds of cognitive meta-representations, even if they do not possess explicit models of their own mind (see Beran, 2019; Carruthers, 2014; Carruthers and Williams, 2022; Smith et al., 2019). The GAM makes no precise assumptions about the sophistication of executive/metacognitive processes and their explicit/implicit modes of operation, which are obviously going to vary quite dramatically across species.

On the input side, the IGPS receives goals from various sources including emotion mechanisms, which in turn are mainly activated by motivational systems. This is a notable point of difference with the CLARION architecture. Similar to the GAM, CLARION includes both implicit drives and explicit goals; the metacognitive component of the architecture receives information about the current strength of the organism's drives, and uses this information to set new goals and manage the goal structure (Sun, 2009, 2018). In the GAM, emotions provide the IGPS with urgent emotion-specific goals and/or "stop signals" that instruct the IGPS to terminate or suspend currently active goals. In other words, motivational systems in the GAM can generate instrumental goals through the activation of emotion mechanisms, instead of just feeding information about the state of the organism's drives to higher-level cognitive processes.

The notion that emotions generate high-priority goals for the individual is a key postulate of the coordination approach (Al-Shawaf et al., 2016; Tooby and Cosmides, 1990, 2008) and the main focus of motivational theories of emotions, such as those proposed by Miceli and Castelfranchi (2015) and Scarantino (2014). In the language of Scarantino's theory (partly based on previous work by Frijda (1986, 2007)), the emotion-generated goals of the GAM correspond to *relational goals*, which are defined by an abstract desired result (e.g., removing the offending object in the case of disgust) but do not specify the concrete sub-goals that may be used to reach the result (throw away the object, step away from it, wash it away, etc.). These abstract goals are evaluated by the IGPS in terms of their importance/urgency and their compatibility with the existing goal structure; as a result, the goal structure may be rearranged to include the new emotion-generated goals, derive concrete sub-goals, and so forth.[4] Emotion-generated goals are often accorded precedence, but this is not necessarily the case—it all depends on what other goals are currently active and on *their* urgency and importance (this is described as *compatibility control* in Scarantino's motivational theory). The IGPS may plausibly use the intensity of an emotional episodes to compute the value of the corresponding emotion-generated goal, compare it with those of other active goals, and determine their relative priority.[5]

As with motivational systems, the activity of the IGPS is modulated by mood programs, which modify their overall functioning parameters and thus change the "style" with which an individual approaches the pursuit of instrumental goals. For example, reducing the depth of goal hierarchies by excluding (or downweighting) their higher and more abstract levels will yield a shorter time horizon and privilege concrete, short-term goals over long-term objectives; conversely, deeper hierarchies will lengthen the time horizon and reduce the weight of immediate incentives and threats.[6] Other potential parameters of the IGPS that are plausibly affected by mood changes include the rigidity vs. volatility of goal priorities (i.e., the facility with which existing high-priority goals can be displaced by new ones); the persistence of goal striving in the wake of perceived failure or lack of progress; and the stringency of the system's criteria for determining success vs. failure. As I discuss below, these same parameters can give rise to stable personality differences if they vary consistently across individuals.

3.2.2. Procedural emotions

Some authors conceive of instrumental goals as a form of behavior regulation that relies on perceptual and cognitive feedback, but does not depend on emotions (e.g., Schultheiss, 2021). In practice, however, even a minimal goal like making the bed or hammering a nail into the wall can evoke a fairly broad range of emotions, from frustration and angry irritation to disappointment to satisfaction—in addition to fuzzier positive/negative feelings about the rightness or wrongness of the outcome of our actions (is the nail sticking out at the right angle?). What characterizes this subset of "procedural" emotions is that they are evoked by instrumental goal pursuit per se, regardless of the specific content of the goal. In the GAM, procedural emotions are the only emotions directly triggered by the IGPS; they contribute to regulate instrumental goal pursuit by calling for changes in the priority of alternative goals; prompting the allocation of additional effort or the withdrawal of effort from the task; sending "stop signals" when a goal has been achieved or should be abandoned; and so forth.

An important kind of problem that is routinely faced by the IGPS is the possibility of conflict between competing active goals. When a conflict cannot be resolved by goal management algorithms, the emotional response is one of anxiety, or—to use a more precise label—*anxious indecision*. Anxious indecision prompts the individual to engage in assessment strategies, which can be behavioral (e.g., cautious exploration) as well as cognitive (e.g., rumination). Note that indecision can arise from competition of all sorts of goals—not just where the dilemma is between achieving a reward and avoiding a threat, but also when conflicts arise between mutually exclusive opportunities or alternative sources of harm.

The intensity of procedural emotions is proportional to the importance and urgency of the goal(s) they are tracking. When one is hanging a picture to the wall, hammering a nail in the wrong place may evoke no more than mild irritation; when one is about to finish an expensive and time-consuming cabinetry project, hammering a nail in the wrong place can be the cause for serious distress. At the same time, procedural emotions generate their own goals (e.g., "try harder"); the urgency and importance of these new subgoals in the IGPS is partly determined by the intensity of the generating emotions. This dynamic helps sustain the pursuit of high-priority goals in the face of obstacles and setbacks.

The idea that emotions regulate goal pursuit in a general, domain-independent fashion has been expressed several times in the literature on motivation. For example, Uusberg et al. (2019) argued that striving to minimize gaps in the feedback loops that control actions yields an intrinsic "competence motive", which gives rise to feelings like frustration and boredom. Carver and Scheier (2013, 2014) built on Simon's (1967) classic hypothesis that emotions work as "calls for reprioritization" in the management of goal hierarchies, and proposed that emotional valence tracks the rate at which the action system reduces the discrepancies between goals and outcomes (positive valence when progress is faster than expected, negative when progress is slower). However, these abstract formulations of the role of emotions are not easy to square with the fact that many emotions (e.g., fear vs. relief; shame vs. pride) seem to track the achievement of domain-specific goals

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[4] A minor difference between the GAM and Scarantino's (2014) motivational theory is that, in the former, emotions can generate either goals or "stop signals" that terminate existing goals; whereas in the latter, all emotions generate relational goals, some of which have a "negative" content (e.g., "not relating as such" in the case of sadness).

[5] Also note that, following the distinctions made by Miceli and Castelfranchi (2015), some of the goals generated by emotions may have the quality of "desires" or "wishes" (e.g., wishing the misfortune of another person in the case of envy).

[6] For an early account of how the depth of a goal hierarchy can dramatically affect the dynamics of motivation, see Raynor (1969).

rather than just "progress" in general, and arise only in certain physical or social situations (see e.g., Nesse, 2004; Nesse and Ellsworth, 2009). By distinguishing between a general-purpose IGPS and specialized motivational systems, and identifying procedural emotions as the subset of emotions activated by the IGPS, the GAM adds clarity and precision to previous accounts of emotions in goal-directed behavior.

3.2.3. Individual differences

Individual differences in the management of instrumental goals have received much less attention than those in the functioning of motivational systems. Still, taking into account the existence of variability in the parameters of the IGPS is absolutely crucial for any theory of personality. In a previous section, I offered a tentative list of four such parameters: the depth of goal hierarchies (which corresponds to the time horizon of active goals), the rigidity of goal priorities, the persistence of goal striving in the face of failure (or lack of progress), and the stringency of the criteria for determining success. Differences in these functioning parameters—which are likely to show meaningful patterns of reciprocal correlations—can have substantial effects on individual patterns of behavior and emotion; they are reflected in personality traits such as conscientiousness, impulsivity, constraint, and perfectionism. Of course, the importance of these dimensions of variation is going to depend quite a bit on the species one is considering: individual styles of goal pursuit should have the most far-reaching and consequential effects on behavior in animals (primarily humans) who are able to follow complex plans, and manage deep hierarchies of goals with distant time horizons.

Previous attempts to reconstruct personality from models of motivational processes have suffered from the lack of a conceptual equivalent of the IGPS. For example, the affective neuroscience model proposed by Davis and Panksepp (2011, 2018) and used to develop the Affective Neuroscience Personality Scales (ANPS) is based on six basic emotional systems (SEEKING, PLAY, CARE, PANIC/Sadness, RAGE, and FEAR).[7] The resulting traits show sizable correlations with Big Five agreeableness, extraversion, neuroticism, and openness, but are only weakly related to conscientiousness (see Davis and Panksepp, 2018). As I noted earlier, Read et al. (2010) simulated individual differences in disinhibition vs. constraint by varying the strength of reciprocal inhibition between different motives; this is a clever expedient, but motivational persistence alone cannot account for the rich phenomenology of the traits mentioned in this section.

In conclusion, individual variation in IGPS parameters plays an important role in the GAM, and may prove indispensable to account for personality variation in the sphere of impulsivity, persistence, constraint, and similar traits. At the same time, variability in the domain of instrumental goal pursuit is still largely unexplored, and much of my discussion in this section is—by necessity—initial and highly speculative. Among the many questions that await an answer: does the IGPS rely on specific regulatory variables and/or internal working models, similarly to specialized motivational systems? And if so, what is the content of those variables and models? Two natural candidates are (a) expectations about the predictability/controllability of future outcomes, and (b) expectations of competence and success; most likely, these suggestions only scratch the surface of the problem. Two crucial tasks in future developments of the GAM will be fleshing out the functional logic of the IGPS by integrating existing research on the cognitive dynamics of goal management (e.g., Kruglanski et al., 2015; Vancouver, 2018), and finding effective, economical ways to describe individual differences in instrumental goal pursuit.

3.3. Approach-avoidance mechanisms

Approach and avoidance are the basic polarities of motivation, and the mechanisms that prompt organisms to move toward or away from certain stimuli are phylogenetically very ancient (see McNaughton et al., 2016). However, the precise role of approach-avoidance mechanisms in the architecture of motivation remains surprisingly hard to pin down after many decades of research (Elliot et al., 2013). Some theorists conceptualize approach and avoidance as superordinate systems (e.g., Carver and Scheier, 2013) or distinct categories of motives (e.g., Read et al., 2010). But the motivational systems approach I introduced earlier makes it apparent that, in many cases, the same underlying motive can induce both approach and avoidance depending on context (approach food when hungry, avoid it when too full; avoid dominant individuals, approach subordinates; etc.). From this standpoint, approach and avoidance are best understood as "tactics" to be deployed strategically in relation to fundamental goals such as self-preservation, mating, and status. Even the classic idea that positive stimuli (rewards) motivate approach while negative stimuli (threats/punishments) motivate avoidance turns out to be untenable, since anger and other negative emotions can trigger strong approach tendencies toward aversive objects and situations (Harmon-Jones et al., 2013).

The best solution to these puzzles and inconsistencies seems to postulate that approach and avoidance mechanisms work as downstream general-purpose effectors for a host of other mechanisms in the architecture—primarily emotions, but also motivational systems and moods. This conception of approach-avoidance mechanisms is embedded in the structure of the GAM (Fig. 1). If approach and avoidance are shared output pathways for other domain-specific systems, they can be recruited as needed, regardless of the valence of the stimulus. Importantly, the *phylogenetic* priority of approach and avoidance does not mean that the corresponding mechanisms have retained *control* priority as nervous systems have evolved and increased in complexity. In fact, a plausible scenario—consistent with the coordination approach—is one in which emotions evolved precisely to coordinate approach and avoidance with a host of other cognitive and physiological responses. When emotion mechanisms are activated, they can trigger nonspecific, directional impulses toward approach or avoidance *and* specific action tendencies that prepare the motor system for particular kinds of actions (e.g., running, hitting).

3.3.1. Reframing Reinforcement Sensitivity Theory

Reinforcement Sensitivity Theory (RST) is by far the most influential model of motivation and personality based on the concepts of approach and avoidance (Corr, 2008; Gray and McNaughton, 2000). It is so influential that other personality theorists have started to explicitly incorporate the constructs of RST into their own computational models (Brown and Revelle, 2021; Read et al., 2018). In a nutshell, the theory postulates the existence of three neurobiological systems that regulate behavior in the context of approach (the *behavioral approach system* or BAS); avoidance (the *fight-flight-freeze system* or FFFS); and motivational conflicts, typically between approach and avoidance (the *behavioral inhibition system* or BIS). The characteristic emotion of the FFFS is fear; in contrast, the BIS deals with approach-avoidance conflicts by triggering anxiety and prompting risk-assessment behaviors in the form of "defensive approach" or "passive avoidance" (Corr, 2008, Corr & Krupić, 2017; McNaughton et al., 2016).

The chief appeal of Reinforcement Sensitivity Theory is its remarkable parsimony; however, the more recent renditions of the theory emphasize that the BIS, BAS, and FFFS are not unitary but heterogeneous, and distributed across multiple levels of the neural hierarchy (e.g., McNaughton et al., 2016). In particular, the initial conception of the BAS as a single reward/incentive system has evolved toward a complex, multifaceted view according to which the BAS comprises at least three functionally distinct aspects: responsiveness to rewards (linked to impulsivity and reduced constraint/conscientiousness), goal/drive

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[7] Davis and Panksepp's personality model leaves out the LUST system but (oddly enough) includes a "spirituality" dimension, for a total of seven traits.

persistence (linked to elevated constraint/conscientiousness), and consummatory pleasure seeking (Corr and Krupić, 2017). The theory also struggles to explain why the BIS should be recruited to deal with conflicts between multiple rewards ("approach-approach conflicts"; see Corr and Krupić, 2017), which may arouse anxiety but do not seem to require defensive approach or risk assessment behaviors. All these considerations suggest that the three neurobiological systems hypothesized by the original theory can be "deconstructed" and redescribed in terms of multiple distinct mechanisms; the GAM provides the conceptual tools to do so.

From the perspective of the GAM, the FFFS maps neatly on the combination of two ubiquitous motivational systems, *fear* and *defensive aggression*. These systems are strongly coupled in their activity (Panksepp, 1998), and it is largely a matter of preference to describe them individually or as components of a broader system like the FFFS (see Del Giudice, 2022). That said, the GAM underscores the fact that avoidance tendencies are associated with many different emotions—for example shame and disgust—and are by no means uniquely linked to fear. As discussed earlier, each motivational system processes its own-domain specific cues of danger and threat (when relevant); to the extent that the sensitivities of multiple motivational systems are positively correlated, they will give rise to a generalized dimension of threat sensitivity.

The case of the BAS is more interesting. Because different motivational systems respond to different cues of opportunities, "responsiveness to rewards" in the GAM is a highly distributed property rather than the product of a single mechanism. However, positive correlations between parameters can give rise to a generalized dimension of sensitivity to opportunities that, if viewed through the lens of reinforcement sensitivity, would look like an index of BAS responsiveness. In contrast, the "drive persistence" aspect of the BAS is taken up by the IGPS, whose functioning parameters determine the "stickiness" of current goals and their stability in the face of failure.

Finally, in the GAM, the functions attributed to the BIS are carried out by two separate mechanisms with different roles within the architecture. Defensive approach and risk assessment in the face of potential threats—i.e., threats that are hard to detect but may have catastrophic consequences, such as hidden predators—are the specialized responses of the *precaution* system (Boyer and Liénard, 2006; Woody and Szechtman, 2011; see Del Giudice, 2022). The activity of the precaution system is associated with anxiety; but precautionary anxiety must be distinguished from anxious indecision, which is a procedural emotion triggered by the IGPS in response to unresolved conflicts between instrumental goals. Importantly, the conflicts that may evoke indecision are not limited to those involving threats vs. opportunities ("approach-avoidance"), but extend to cases of alternative threats ("avoidance-avoidance") as well as alternative opportunities ("approach-approach"). Thus, the GAM differentiates between two functionally distinct kinds of anxiety that remain uneasily mixed up in the standard conceptualization of the BIS.

3.3.2. Individual differences

Turning to individual differences, one implication of the preceding sections is that approach-avoidance mechanisms per se should play a secondary role in personality variation. In the GAM, different profiles of approach and avoidance tendencies are largely a downstream consequence of variability at the upper levels of the control hierarchy (e.g., patterns of correlated parameters across motivational systems, individual differences in the activity of mood mechanisms). However, there is also room for some parametric variation in approach-avoidance mechanisms themselves. For example, the sensitivity of approach-avoidance mechanisms—i.e., the intensity of the behavioral outputs produced in response to the same inputs from emotions and moods—may vary systematically between individuals, yielding more or less vigorous action tendencies all else being equal.

3.4. Other aspects of the GAM

In addition to the main components examined in this section, the diagram in Fig. 1 includes a number of other pathways that are less central to the functioning of the architecture. For example, the arrow from physiological systems to motivational systems represents the fact that certain motivations (such as feeding/hunger or mating) are partially controlled by inputs about the organism's physiological state. Another aspect of the GAM that I have not yet discussed is the class of what I will call *noetic emotions*—emotions that arise in the context of prediction, prediction errors, information-gathering, and the consolidation or revision of internal models (see Miceli and Castelfranchi, 2015; Uusberg et al., 2019). Noetic emotions such as surprise, interest, puzzlement, and amusement[8] can powerfully motivate behavior; indeed, in a previous section I postulated the existence of a specialized *curiosity* system (not unique to humans, but shared with other species) that activates these emotions in the service of exploration and learning (Del Giudice, 2022; see above). At the same time, noetic emotions arise constantly in the very process of perceiving and modeling the world; they represent a basic feature of psychological functioning at the interface of perception, thought, and motivation. Because action and knowledge are deeply intertwined, there is some overlap between noetic and procedural emotions (Fig. 1). A notable example is *boredom*, which may arise when performing tasks perceived as repetitive and meaningless (i.e., disconnected from important and/or urgent goals), but also when faced with information that is irrelevant or too predictable (see Lin and Westgate, 2022). Fig. 1 includes noetic emotions for completeness; I leave a detailed analysis of this aspect of the architecture to future revisions and extensions.

4. From the GAM to personality models

A motivational architecture like the GAM is only the first step on the road to realistic, theoretically meaningful models of personality. In this section I briefly look at the bigger picture and present a roadmap for future research.

4.1. Structural vs. functional models of personality

To begin the discussion, it is important to draw a distinction between *structural* and *functional* models of personality. Structural models summarize the statistical relations among indicators in a parsimonious, interpretable way. The most popular structural models in human and animal research—such as the Five-Factor Model (FFM, often referred to as the "Big Five"; Goldberg, 1990; McCrae and Costa, 2008), the HEX-ACO (Ashton and lee, 2007), and the various FFM-derived models of personality in primates (Weiss, 2017)—have been constructed using factor analysis or principal component analysis (PCA). However, patterns of covariation can be summarized with many other methods, including multidimensional scaling (MDS; e.g., Dutton and Anderson, 2002) and network modeling (e.g., Costantini et al., 2019; Mõttus and

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[8] For an extremely insightful analysis of the functional connections between humor, amusement, and prediction errors, see Hurley et al. (2011).

Allerhand, 2018). These correlational methods can be informative and extremely helpful in all sorts of applications, but they are generally unable to identify the mechanisms and processes that underlie the observed covariation among indicators, except in unrealistic toy scenarios.[9] This crucial limitation has been understood for decades (e.g., Cloninger et al., 1993; Lykken, 1971; Revelle, 1983), and has been pointed out in a number of recent publications on motivation and personality (Baumert et al., 2017; Davis and Panksepp, 2018; Del Giudice, 2022; Lukaszewski, 2021; Lukaszewski et al., 2020).

Instead of starting from patterns of covariation between indicators, functional approaches start from a model of the underlying mechanisms and processes. Both Reinforcement Sensitivity Theory and Davis and Panksepp's affective neuroscience model have been used to build functional models of human personality, in which trait descriptions are derived from assumptions about mechanisms. The GAM is a general framework that allows researchers to build detailed species-specific models of this kind by "filling the blanks" of the architecture (e.g., specifying the number and nature of a species' motivational systems; see below). Once a concrete functional model is available, it can be used to derive trait-like dimensions that summarize individual differences in the parameters and/or outputs of the relevant mechanisms, as I have discussed in the preceding sections. Uncovering the nature and meaning of those differences is a complex task that can be approached with a variety of research tools—from empirical studies to mathematical models, including evolutionary models that explicitly track the fitness consequences of individual variation (see Brommer and Class, 2017; Carere and Maestripieri, 2013; Međedović, 2018). In this context, correlational methods may be used to help summarize certain patterns of variation, but not as stand-alone tools to identify the underlying mechanisms.

As a rule, "functional traits" should not be expected to behave like the familiar "structural traits" of the FFM and other factor models. In functional models, biological meaningfulness and mechanistic accuracy take precedence over parsimony and descriptive simplicity; thus, one can expect functional traits to show a lot of redundancy and fairly intricate patterns of covariation. This is not a limitation of functional models but their very raison d'être. Criticizing a functional model of personality because the traits are too many, too redundant, or fail to conform to a statistical "simple structure" (see Browne, 2001) would be a mistake—the criteria for a "good" structural model are simply irrelevant to the aims of functional modeling. Naturally, this does not mean that the traits derived from functional models will never show similarities and correspondences with those emerging from structural approaches. For example, a higher-order dimension of generalized sensitivity to threats in a GAM-derived model would overlap substantially with neuroticism in the FFM. Indeed, a comprehensive functional model of personality should be able to reproduce the findings of structural approaches, by applying standard correlational methods to measures of the model's functional traits (or a suitable subset thereof).

In the human personality literature, there have been some notable attempts to bridge the structural-functional gap by directly interpreting the traits of structural models in functional terms. Most notably, Denissen and Penke (2008), Van Egeren (2009), and DeYoung (2015) argued that the Big Five can be viewed as operating parameters of core psychological processes (e.g., trait extraversion as the reward value of social interactions, or the individual's general sensitivity to rewards). Ashton and Lee (2001, 2007) did the same with the HEXACO. These papers provide a wealth of useful insights; however, their characterization of the functional meaning of structural traits suffers from a certain vagueness (e.g., extraversion clearly includes aspects of dominance and status-seeking that go beyond a generic "reward sensitivity"), and ultimately fails to add up to a convincing model of motivation. From the perspective of the GAM, the main reason is that the authors have taken the statistical factors of the FFM and HEXACO at face value, instead of viewing them as helpful but somewhat arbitrary summaries of a much more complex set of underlying processes.

4.2. Functional modeling with the GAM: static descriptions and dynamic computations

To build a comprehensive model of personality on the foundation of the GAM, researchers would have to go through seven steps: (1) map the motivational systems of the species of interest, and decide which systems will be included in the model (e.g., feeding and thermoregulation may not be regarded as essential, at least in human research); (2) use empirical studies and/or mathematical modeling to detail the functional logic of motivational systems (which may include regulatory variables and internal working models); (3) determine the species-specific capabilities and constraints of the IGPS; (4) identify a suitable set of operating parameters for motivational systems and the IGPS that can be used to describe individual differences and derive lower-order functional traits; (5) map the correlations among those parameters and other important patterns of covariation (e.g., fast-slow life history strategies), which can be used to derive higher-order functional traits; (6) specify the operating parameters of mood and approach-avoidance mechanisms, which can also contribute to the emergence of higher-order traits; and (7) describe patterns of reciprocal modulation between motivational systems and top-down coordination via mood programs.[10]

However, a functional model of personality does not have to be fully specified to the last detail in order to be meaningful and informative. Even a rough approximation of steps 1–4 based on a simple parametrization of motivational systems (e.g., activation sensitivities) can provide a useful "first draft" of a model, similar to Reinforcement Sensitivity Theory and Davis and Panksepp's affective neuroscience scales. Adding more detail about the architecture's operating parameters (e.g., deactivation sensitivities, regulatory variables), mapping their correlations, and deriving a set of higher-order traits (step 5) would yield a more sophisticated model than most of those in the current literature.

Until now, I have been talking about *static* models of personality—the kind of description that focuses on stable parameters and behavioral profiles, and characterizes each individual as a fixed combination of trait values. In reality, what static models provide is just the averaged-out summary of a complex interplay between mechanisms that unfolds over time and situations (Revelle and Wilt, 2021). To capture this interplay and become able to explain within-individual variability, one needs to go beyond static descriptions and build an explicit *dynamic* model of motivational processes. Functional models of personality can handle the shift to a dynamic perspective with relative ease, as they are intrinsically process- and mechanism-oriented. In contrast, structural models struggle to account for within-individual variation, because individual differences in patterns of covariation over time change the very content and meaning of the model's traits; as a result, each individual

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[9] In synthesis, the main reasons are: (a) the operation of a single mechanism may not translate into simple patterns of associations among the mechanism's outputs, especially if those outputs are context-dependent and the mechanism is regulated by multiple parameters and internal variables. (b) Between-individual associations among indicators do not just reflect the functioning of individual mechanisms, but also patterns of correlations between the operating parameters of different mechanisms and reciprocal modulation effects. (c) Different mechanisms may produce phenotypically similar outputs; this problem is compounded when linguistic descriptors are used, and the same label (e. g., "anxiety") is applied to the output of functionally distinct kinds of mechanisms (e.g., precautionary anxiety, separation anxiety, anxious indecision, etc.). See Del Giudice (2022) and Lukaszewski et al. (2020).

[10] Note that this list sidesteps the methodological issue of how exactly to operationalize and measure the model's traits; this issue may be addressed in a number of alternative ways (rating scales, behavioral tasks, self-reports…) depending on the species of interest and the context of utilization of the measures.

may end up requiring a different, idiosyncratic model, with a dramatic loss of generalizability and theoretical coherence (see e.g., Beck and Jackson, 2020, 2021).

The two best-known dynamic functional models in the personality literature are the CTA model by Revelle and Condon (2015); Brown and Revelle (2021), which adapts and streamlines Atkinson and Birch's (1970) Dynamics of Action, and the neural network models by Read et al., (2010, 2017, 2018). Sun and Wilson (2014) also carried out some dynamic personality simulations with the CLARION architecture. All these models rely on computational methods to simulate within-individual patterns of behavior over time; inevitably, they introduce drastic simplifications to the processes they describe, both to make the simulations tractable and because we still know relatively little about the exact computational logic of the relevant psychological mechanisms.

The model of motivation embodied by the GAM is considerably more complex than the alternatives, and includes several mechanisms that are functionally important but still incompletely understood (e.g., motivational systems, mood mechanisms, or the IGPS). For this reason, using the GAM to derive a fully specified dynamic model of personality is not a realistic objective at the present time. However, it should be feasible to build "toy models" based on pared-down adaptations of the GAM. For example, a restricted model consisting of a small number of motivational systems, a simplified model of the relevant emotions, and a bare-bone version of the IGPS could still prove useful to describe the basic interplay between situational features, motivational states, emotions, and behaviors. Such a model could yield some novel insights and predictions that could be tested against the empirical data, and potentially used to revise and refine the broader architecture. A corollary is that, for the time being, static functional models can afford to be more realistic, even if they lack the mechanistic precision of dynamic models; to illustrate, researchers can describe and measure individual differences in attachment styles even without a detailed computational model of the attachment system (but see e.g., Chumbley and Steinhoff, 2019; Petters and Beaudoin, 2017). Finally, the GAM is designed to account for the phenomena captured by classic structural models like the FFM and HEXACO; but it may require human-specific extensions to deal with some additional dimensions of variation that sit at the interface between motivation and cognition, as for example autistic-like and schizotypal traits (see Andersen, 2022; Blain et al., 2020; Crespi, 2020; Crespi and Badcock, 2008; Del Giudice et al., 2014; Wakabayashi et al., 2006).

5. Conclusion

To realize the dream of an integrated science of personality, researchers will have to move beyond structural descriptions and start building realistic functional models of individual differences. I believe that ground-up adaptationism guided by evolutionary theory is the way of the future (Lukaszewski, 2021); however, I also believe that the effort spent in teasing out the logic of specific mechanisms (e.g., the anger program; Lukaszewski et al., 2020; Sell et al., 2017) will not pay off in the domain of personality without the scaffolding of a broader theory of motivation—and an architectural framework to link the mechanisms together and explain their dynamic interplay.

In this paper, I have built on previous contributions to present the initial version of the GAM, a general motivational architecture that can be adapted to fit a broad range of animal species. The framework of the GAM should make it easier to integrate theoretical and empirical results from a variety of research areas, develop functional models of personality, and—not least—compare the personality of different species based on explicit functional principles (e.g., different sets of motivational systems, differences in activation/deactivation parameters), thus overcoming the limitations of standard factor-analytic descriptions. As I noted in the introduction, the GAM is intended as a work in progress, open to integrations and revisions. I hope this proposal will stimulate the curiosity of other scholars and spark the kind of creative, integrative

work that can bring the science of personality to its well-deserved maturity.

Data Availability

No data was used for the research described in the article.

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