The Predictive–Interoceptive Processing Model

Regulatory Efficiency, Allostatic Load, and Human Health Behavior

By

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During manuscript preparation, AI-assisted tools were used for language refinement, grammar checking, consistency review, and limited support with the formatting of tables and figures. The theoretical framework, conceptual development, selection and interpretation of the literature, argumentation, and all final manuscript decisions are the author's own. The author reviewed and revised all AI-assisted suggestions and takes full responsibility for the book's content.

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Preface

This book presents the PIP Model as a regulatory framework for understanding embodied change, health, and human behaviour. Its central aim is to clarify how human behaviour is not only shaped by knowledge, intention, motivation, habit, or environment, but also by the regulatory mode through which experience and action are organised.

The model developed in this book proposes that human change cannot be fully understood by examining behavioural content alone. The same behaviour may have different biological, psychological, and functional consequences depending on whether it is enacted through reactive control, anticipatory tension, and high regulatory cost, or through context-sensitive coordination, greater interoceptive coherence, and proportionate, recoverable mobilisation.

The PIP Model therefore shifts attention from what a person does to how they are regulated while doing it. This distinction is central to the book's argument. It allows behaviour, health, performance, stress, recovery, motivation, and lifestyle to be examined through a common regulatory lens.

The book integrates insights from interoception, allostasis, stress physiology, autonomic regulation, predictive processing, behaviour change, physical activity, embodiment, and recovery. It does not claim to replace these fields. Rather, it proposes an additional explanatory layer that may help organise their findings into a coherent account of human regulation.

The framework is theoretical and integrative, but it is also intended to be testable. Throughout the book, the PIP Model is presented as a testable framework requiring further empirical examination, refinement, and validation. Its value lies not in offering a final explanation, but

in identifying a regulatory process that may be central to sustainable change, health, optimal performance, and human functioning.

The book is written for researchers, clinicians, educators, health professionals, and students interested in the relationship between bodily regulation, behaviour, and human experience.

Chapter 1

Introduction: The Regulatory Problem of Human Change

People commonly explain human change through knowledge, motivation, intention, habit, discipline, environmental opportunity, and social support. Each is important, yet none fully explains why people often fail to sustain behaviours they understand, value, and intend to maintain. This book addresses the gap between knowing, intending, and sustaining change.

The PIP Model approaches this problem from a regulatory perspective. It proposes that behaviour cannot be adequately comprehended by examining only what a person does; it is also necessary to consider how the behaviour is generated, experienced, adjusted, terminated, and followed by recovery. Externally similar actions may differ in subjective effort, physiological mobilisation, attentional demand, corrective control, flexibility, and future capacity.

An externally adaptive behaviour may therefore arise through different regulatory pathways. These pathways may differ in anticipatory mobilisation, self-monitoring, responsiveness during action, capacity to deactivate, and recovery demand. The relevant distinction is not between effortful and effortless behaviour, but between effort that remains proportionate and recoverable and effort that becomes unnecessarily persistent or difficult to adjust. The model draws on research concerning homeostasis, allostasis, interoception, autonomic regulation, stress physiology, predictive processing, embodiment, and behaviour change. These fields indicate that human functioning involves ongoing prediction, bodily regulation, environmental inter-

action, adaptation, and recovery (McEwen and Stellar, 1993; Craig, 2002; Sterling, 2012; Barrett and Simmons, 2015; Seth and Friston, 2016). The PIP Model does not replace these traditions; it organises selected insights around the proposition that the regulatory pathway through which behaviour is enacted may influence its cost, flexibility, and sustainability.

The model therefore introduces a proposed regulatory level of analysis for examining the relationship between behavioural content and longer-term outcomes. This level concerns how bodily information, expectation, attention, meaning, action, and recovery are coordinated during repeated behaviour. It may help explain why the same recommendation can be manageable for one person, costly for another, and differently experienced by the same person across changing states and contexts.

Regulatory mode does not operate independently of social conditions, material resources, health status, developmental history, culture, relationships, opportunity, environment, or structural constraints. The PIP Model examines one potentially important layer through which these influences are embodied and enacted. This chapter defines the regulatory problem of human change, distinguishes behavioural content from regulatory organisation, and establishes the model's scientific boundary as an integrative and testable framework whose constructs require operationalisation and empirical evaluation.

1.1 The limits of content-based explanations of behaviour

Many theories and interventions begin with behavioural content: what a person eats, how much the person moves, how long the person sleeps, which goals are pursued, or how consistently a prescribed action is completed. This approach has clear practical value because

behavioural targets can be observed, quantified, communicated, and evaluated across clinical practice, public health, education, rehabilitation, and performance settings.

Behavioural content alone, however, provides limited information about the regulatory process producing the action. Two people may complete the same exercise session, follow the same dietary recommendation, or perform the same rehabilitation task while differing substantially in bodily mobilisation, attention, affect, self-monitoring, perceived threat, and recovery. One may remain engaged and adjust effort according to current capacity; another may depend on anticipatory tension, rigid comparison, fear of failure, or continuous numerical feedback. The observable behaviour is similar, but the regulatory pathway and later consequences may differ. Such differences may remain undetected when evaluation is limited to frequency, duration, adherence, or immediate performance. Completion does not reveal how much anticipatory mobilisation was required, whether adjustment remained possible during the activity, how readily activation ended, or how much recovery followed. Behaviour occurs within a living system. Every action is shaped by physiological state, interoceptive and environmental information, prior learning, affective meaning, fatigue, attention, and available recovery capacity. Behaviour should therefore be understood both as an outcome of regulation and as a means through which the organism modifies internal and external conditions. Eating, movement, rest, withdrawal, social contact, environmental selection, and information seeking can alter bodily state and perceived demand, thereby contributing to the continuation, correction, or restoration of regulation.

A content-based account may also underestimate why beneficial behaviours become aversive or unstable. Physical activity, for example, may be medically advisable while being experienced as threatening, humiliating, excessively effortful, or closely linked to compari-

son and self-evaluation. The difficulty may arise not from insufficient knowledge of its benefits but from associations with high anticipatory cost, bodily vigilance, social judgement, or repeated correction. Comparable discrepancies may occur across sleep, dietary change, rehabilitation, work, learning, and professional performance. These domains are examined later; the present point is that the recognised value of a behaviour does not determine how it is predicted, experienced, or regulated.

The PIP Model therefore distinguishes behavioural content from regulatory organisation. Content describes what the person does. Regulatory organisation concerns how bodily signals, prediction, attention, meaning, control, action, and recovery are coordinated while the behaviour occurs. The distinction is analytical rather than absolute: repeated action may alter expectation, confidence, bodily interpretation, habit, and recovery, while regulatory conditions influence whether action is initiated, modified, avoided, or repeated.

Appropriate behavioural content remains essential. Movement, nutrition, medication use, sleep, social context, environmental opportunity, and material conditions are central to health and functioning. The narrower claim is that their consequences may vary according to the regulatory conditions under which they are enacted. The PIP Model therefore supplements rather than replaces behavioural, psychological, physiological, and social explanations. It does not suggest that unsuccessful change always results from inefficient internal regulation or that adaptive regulation can overcome illness, deprivation, unsafe environments, disability, inadequate resources, or structural constraints.

This additional level of analysis may help explain why information, goal-setting, external monitoring, and instruction sometimes produce short-term change without stable maintenance. Such approaches may alter the target behaviour while leaving anticipation, threat appraisal,

corrective control, or inadequate recovery substantially unchanged. The central question is therefore not only whether a beneficial behaviour occurs, but how it is initiated, sustained, adjusted, terminated, and followed by recovery across repeated episodes. Regulation may be considered more proportionate when mobilisation corresponds sufficiently to actual demand, remains responsive to new information, and can be reduced after its function has ended. Adaptive behaviour need not be easy, comfortable, or associated with low activation. Learning, rehabilitation, physical training, protection, and meaningful achievement may require substantial effort. The relevant distinction is between functionally required and recoverable demand and additional demand generated by persistent anticipation, excessive self-monitoring, rigid correction, or delayed deactivation.

Behavioural content identifies what is done; the regulatory perspective adds how behaviour is produced, adjusted, and recovered from across repeated episodes. This distinction leads to the next question: why knowledge and intention often fail to produce stable behavioural change.

1.2 Why behaviour change often fails despite knowledge and intention

Knowledge is necessary for many forms of change because people need to understand relevant risks, possible benefits, and available actions. It does not, however, automatically produce behaviour, and initial action does not ensure maintenance. The intention–behaviour gap illustrates this limitation. In physical activity research, many people who intend to be active do not consistently translate that intention into behaviour (Feil et al., 2023). More broadly, health-behaviour maintenance is shaped by self-regulation, habit, affect, reinforcement, reward, environmental cues, and social conditions rather than intention alone (Hennessy et al., 2020; Michaelsen and Esch, 2023; Singh et

al., 2024). An intention must be enacted by an organism that allocates resources, anticipates demand, regulates physiological mobilisation, interprets bodily information, coordinates action, tolerates discomfort, and recovers. Its strength or sincerity therefore does not determine whether the regulatory conditions required for implementation are available.

From the PIP perspective, intended behaviour interacts with the person's current state and context. Exercise, dietary change, improved sleep, stress reduction, or treatment adherence may be consciously endorsed while remaining influenced by fatigue, pain, prior experience, threat prediction, social meaning, perceived effort, environmental opportunity, and available capacity. The same intention may consequently be manageable in one situation and difficult in another. Variation in implementation should not automatically be interpreted as variation in commitment.

This distinction can be expressed as the difference between cognitive acceptance and regulatory integration. Cognitive acceptance means that a person understands and endorses a behaviour. Regulatory integration means that the behaviour has become sufficiently coordinated with bodily state, context, action, and recovery to be repeated without disproportionate regulatory cost. Acceptance may provide direction and commitment, but it does not establish that the behaviour is tolerable, adaptable, or sustainable. Regulatory integration does not imply effortless compliance or complete alignment among intention, bodily state, and context. Integrated behaviour may remain difficult, require deliberate control, and produce temporary fatigue. The relevant issue is whether intensity, timing, strategy, or recovery can be adjusted without abandoning the broader behavioural direction or depending continuously on threat, self-criticism, and rigid correction.

A person may understand the benefits of exercise yet associate it with discomfort, shame, previous failure, social comparison, or excessive

monitoring. Initiation may then require simultaneous regulation of bodily sensation, self-evaluation, anticipated outcome, and perceived threat. Deliberate control may be necessary, particularly during learning, rehabilitation, unfamiliar tasks, and intentional change. It is not inherently maladaptive. The potential problem arises when behaviour remains dependent on intensive monitoring, suppression, self-criticism, or external evaluation. Short-term compliance may then coexist with fatigue, avoidance, reduced motivation, compensatory behaviour, or relapse.

As skill, familiarity, environmental support, confidence, and behavioural organisation improve, deliberate control may become less demanding. The relevant question is not whether control is present, but whether its intensity remains proportionate, decreases with adaptation, or becomes progressively difficult to sustain. Research on motivation and reward supports this dynamic account. Behavioural initiation and maintenance depend on interactions among approach, avoidance, anticipated reward, immediate relief, affective state, and self-regulatory processes rather than conscious intention alone (Michaelsen and Esch, 2021, 2023). Fatigue, sleep, pain, stress, mood, prior experience, and perceived effort can alter whether a valued action appears worth initiating or continuing. Immediate relief may therefore compete with longer-term intention. Avoiding exercise, abandoning a demanding task, consuming rewarding food, or returning to a familiar routine may reduce present discomfort even when a different long-term goal remains endorsed. Such behaviour cannot be explained fully by insufficient knowledge; in some circumstances, it may reflect the greater immediate regulatory value of relief under the person's current condition. Habit formation likewise depends on more than repetition. Habit strength is influenced by frequency, timing, behavioural type, personal choice, affective evaluation, behavioural regulation, and preparatory routines (Singh et al., 2024). Repeated behaviour may become more stable when its regula-

tory conditions reduce conflict, support meaningful engagement, and remain compatible with current capacity.

Repetition may therefore stabilise either adaptive or costly patterns. Behaviour repeatedly performed under pressure, negative affect, excessive monitoring, or inadequate recovery may strengthen expectations of future cost. Under manageable and supportive conditions, repetition may instead permit updating of expectations and reduce corrective control. These propositions remain hypotheses requiring empirical examination. The PIP Model describes one possible configuration associated with costly implementation as the Primed Reactive Mind (PRM). PRM is a proposed mode in which prior learning and self-relevant expectations organise behaviour through disproportionate anticipation, monitoring, comparison, threat-sensitive evaluation, outcome dependence, and corrective control. It may support short-term performance but become relatively costly, rigid, or slow to deactivate when repeatedly dominant. Present-Moment Experience (PME) and Interoceptive Coherence (IC) are introduced only as complementary constructs of the framework; neither implies effortless action or guarantees adaptive outcomes.

Failure to sustain change despite knowledge and intention should therefore not be interpreted solely as irrationality, non-compliance, or insufficient will. In some cases, it may reflect a mismatch among desired behaviour, current capacity, environmental conditions, and the regulatory pathway required for continued action. This interpretation must not transfer responsibility entirely to the individual. Limited resources, unstable housing, unsafe work, caregiving responsibilities, discrimination, illness, disability, restricted access to treatment, and unsupportive environments may make intended behaviour difficult or impossible even when regulation is organised as effectively as circumstances permit.

The PIP Model therefore proposes that stable change may depend not only on selecting or intending a behaviour, but also on the conditions under which it is generated, experienced, repeated, adjusted, and followed by recovery. Knowledge can define direction, intention can organise commitment, and environmental support can create opportunity. Sustainable change may additionally require repeated experiences in which behaviour becomes sufficiently compatible with bodily capacity, contextual demand, learning, and recovery. This provides the transition to the multilevel account of human regulation developed in Section 1.3.

1.3 Human regulation as a biological, psychological, and behavioural process

Human regulation operates across biological, psychological, and behavioural levels. These levels are analytically distinguishable but functionally interdependent. At the biological level, regulation preserves viability while enabling adaptation to changing demands. Autonomic, endocrine, immune, metabolic, cardiovascular, respiratory, and sleep–wake processes interact to maintain variables within viable ranges and to anticipate likely requirements. Stability is therefore achieved through organised change rather than physiological constancy. Mobilisation may support protection, learning, performance, and future capacity, whereas recurrent or insufficiently resolved demand may contribute to cumulative allostatic burden (Guidi et al., 2021; Parker et al., 2022). Chapter 2 examines these mechanisms in detail.

At the psychological level, regulation involves prediction, attention, memory, expectation, affective appraisal, meaning, and self-reference. Responses are shaped not only by external events and circumstances but also by anticipated significance, perceived controllability, identity relevance, social context, and the interpretation of current bodily

signals. Predictive-processing accounts describe perception and action as influenced by prior expectations and ongoing error correction, while interoceptive processing concerns the sensing, integration, interpretation, and regulation of internal bodily signals rather than conscious bodily awareness alone (Chen et al., 2021; Petzschner et al., 2021). Experiences such as fatigue, readiness, effort, anxiety, craving, and emotional activation consequently emerge through interactions among bodily signalling, prior learning, context, and prediction. The PIP Model treats subjective experience as part of regulation because what becomes salient, threatening, effortful, or meaningful may alter mobilisation and action. A modest task may become costly when interpreted as uncontrollable or strongly identity-relevant. In contrast, a demanding activity may remain tolerable when it is meaningful, expected, and proportionate to available capacity. These effects remain context-dependent and do not imply that appraisal can override biological constraints.

At the behavioural level, regulation concerns how the organism acts to maintain, restore, or modify its relationship with the environment. Movement, rest, eating, breathing, work, withdrawal, social contact, sleep routines, digital stimulation, and emotional expression can all influence bodily state and future action possibilities. Behaviour is therefore both an outcome and an instrument of regulation. It may resolve demand, create opportunities for recovery, alter exposure, obtain support, or prepare the organism for later action. It may also provide immediate relief while increasing later cost; avoidance, compulsive checking, excessive stimulation, overwork, or rigid restriction may reduce discomfort without resolving the processes that produced it. These levels do not form a simple sequence from biology to psychology to behaviour. Their relationships are reciprocal: bodily state influences perception and action, psychological meaning alters mobilisation, behaviour changes the body and environment, and resulting consequences update later expectations and responses.

The PIP Model proposes that these interacting processes may become organised into recurring regulatory configurations. Chapters 5–7 distinguish the Primed Reactive Mind (PRM), Present-Moment Experience (PME), and Interoceptive Coherence (IC) as related but non-equivalent constructs whose expression may vary within the same person across demands, health states, learning histories, fatigue levels, perceived safety, social contexts, and recovery conditions. These constructs are proposed functional descriptions rather than separate anatomical systems or fixed personality types.

Contemporary allostatic–interoceptive models provide a conceptual basis for examining bodily prediction, regulation, affect, and behaviour as connected processes. Psychiatric and neurological conditions have been investigated for disturbances in the coordination of allostasis and interoception (Santamaría-García et al., 2025), while reviews of mind–body interventions indicate associations among interoceptive processes, attention to bodily signals, and emotion regulation (Lazzarelli et al., 2024). These findings do not validate the PIP Model or establish its proposed regulatory modes; they support the broader scientific plausibility of examining biological, psychological, and behavioural regulation as interacting components. Human regulation is therefore conceptualised as a multilevel, reciprocal, and temporally extended process. Stable change may be more likely when biological capacity, psychological organisation, behavioural demand, environmental conditions, and recovery are sufficiently compatible. Misalignment among these components is proposed as one possible, rather than universal, reason why consciously endorsed behaviour may remain difficult to sustain. This account provides the basis for the regulatory framework introduced in the next section without reducing human change to either conscious decision-making or physiological processes alone.

1.4 The need for a regulatory framework

Existing behaviour-change theories have substantially advanced understanding of intention, motivation, self-efficacy, habit, environmental cues, social support, and self-regulation. The PIP Model addresses a complementary question: under what organismic and contextual conditions does an intended behaviour become repeatable, adaptable, and recoverable?

Recent reviews describe health-behaviour change and maintenance as dynamic, context-dependent, and involving multiple pathways rather than as a simple progression from intention to action (Wang et al., 2025; Simpson et al., 2025). A regulatory framework extends this perspective by examining how current capacity, bodily state, contextual demand, mobilisation, behavioural adjustment, and recovery interact during behavioural implementation. Its proposed contribution is an output–cost distinction: comparable behavioural outcomes may require different levels of mobilisation, corrective control, flexibility, and subsequent recovery.

The framework is theoretical and hypothesis-generating. PRM, PME, IC, Regulatory Efficiency (RE), regulatory debt, neuroplastic stabilisation, and embodied identity have not been validated as a unified empirical system. Their scientific value depends on whether they can be operationalised, distinguished from established constructs, and shown to provide incremental explanatory value.

Applied implications follow from this distinction. Interventions may alter behavioural targets without changing the regulatory pattern through which they are pursued, allowing temporary improvement without improved sustainability. A regulatory approach therefore extends assessment beyond compliance or behavioural output to include repeated within-person evidence concerning effort, mobilisation, adjustment, and recovery. This interpretation is consistent with

evidence that sustainable health-behaviour change is individualised, nonlinear, and often supported by continuing adaptation rather than one-time instruction (Matthews et al., 2024).

1.5 The scope and aims of the PIP Model

The PIP Model is proposed as an integrative regulatory framework for examining how behaviour and experience emerge through interactions among predictive and priming processes, interoception, context, action, regulatory cost, and recovery. Predictive–Interoceptive Processing (PIP) refers to the interaction between prior learning, expectation, self-relevant prediction, and ongoing bodily information in the organisation of experience and action. Interoception is used broadly to include the sensing, integration, interpretation, and regulation of bodily signals (Chen et al., 2021; Petzschner et al., 2021). Neither predictive processes nor bodily signals are assumed to determine behaviour independently.

The model's central claim is deliberately limited: externally similar behaviours may differ in regulatory organisation, regulatory cost, flexibility, recovery, and sustainability. Lower activation is not inherently preferable, and regulatory mode is not assumed to explain every behavioural outcome. Table 1 summarises the principal concepts and propositions of the PIP Model.

Table 1 *Principal concepts and propositions of the PIP Model*

Concept	Definition in the PIP Model	Regulatory role
Predictive–Interoceptive Processing	The interaction between predictive and priming processes and interoceptive signalling in the organisation of experience and action.	Provides the general process through which behaviour, perception, and self-regulation are organised.
Primed Reactive Mind	A proposed regulatory mode in which anticipation, self-monitoring, comparison, self-relevant evaluation, outcome dependence, and corrective control become disproportionately influential.	May support short-term control or protection, but is hypothesised to increase regulatory cost, rigidity, or demand when repeatedly dominant.
Interoceptive Coherence	A proposed regulatory condition in which bodily information, contextual demand, attention, action, and recovery are sufficiently aligned to permit proportionate and flexible adjustment.	May support context-sensitive pacing, overload recognition, behavioural adjustment, termination of mobilisation, and recovery.
Present-Moment Experience	The lived, embodied interface through which bodily signals, affect, attention, memory, prediction, context, meaning, and action are organised in real time.	Provides the experiential field through which bodily and contextual information becomes available for meaning, action, and behavioural adjustment; it is not inherently an adaptive or low-cost state.
Regulatory Cost	The aggregate physiological mobilisation, attentional effort, experiential strain, and behavioural control incurred within a specific regulatory episode.	Helps distinguish externally similar behaviours that differ in regulatory cost despite comparable observable outcomes.
Recovery Demand	The amount of restoration required after action, stress, effort, or prolonged regulatory activation.	Helps characterise the restorative requirement following behaviour and its potential contribution to cumulative strain when recovery is insufficient.

Concept	Definition in the PIP Model	Regulatory role
Regulatory Efficiency	The degree to which contextually appropriate function is achieved through proportionate mobilisation, limited avoidable cost, flexible adjustment, and recovery that preserves future capacity.	Describes whether behaviour is achieved through context-sensitive, proportionate, adjustable, and recoverable regulation.
Neuroplastic Stabilisation	The gradual stabilisation of repeated regulatory patterns through learning, repetition, attention, and embodied practice.	Describes a proposed process through which PRM-dominant or IC-related regulatory patterns may become more habitual, identity-linked, and behaviourally stable over time.
Embodied Identity	The stabilisation of behaviour and self-experience through repeated regulatory patterns.	Links repeated modes of regulation to self-reference, habit, and long-term change.

Note. PRM, PME, IC, and RE constitute the core constructs of the PIP Model. Predictive–Interoceptive Processing denotes the broader organising process. Regulatory cost and recovery demand are supporting episode-level constructs. Regulatory debt and the Regulatory Rebound Effect are provisional temporal hypotheses, whereas neuroplastic stabilisation and embodied identity are developmental or stabilising propositions. These concepts do not have equivalent empirical status and are intended to guide analysis and empirical testing; they are not validated diagnostic categories. PME describes the experiential interface rather than an inherently lower-cost state. IC concerns contextual integration, not perfect detection or unquestioned trust in bodily signals. PRM is not synonymous with stress, anxiety, prediction, or cognitive control, and RE is not equivalent to successful performance or low activation.

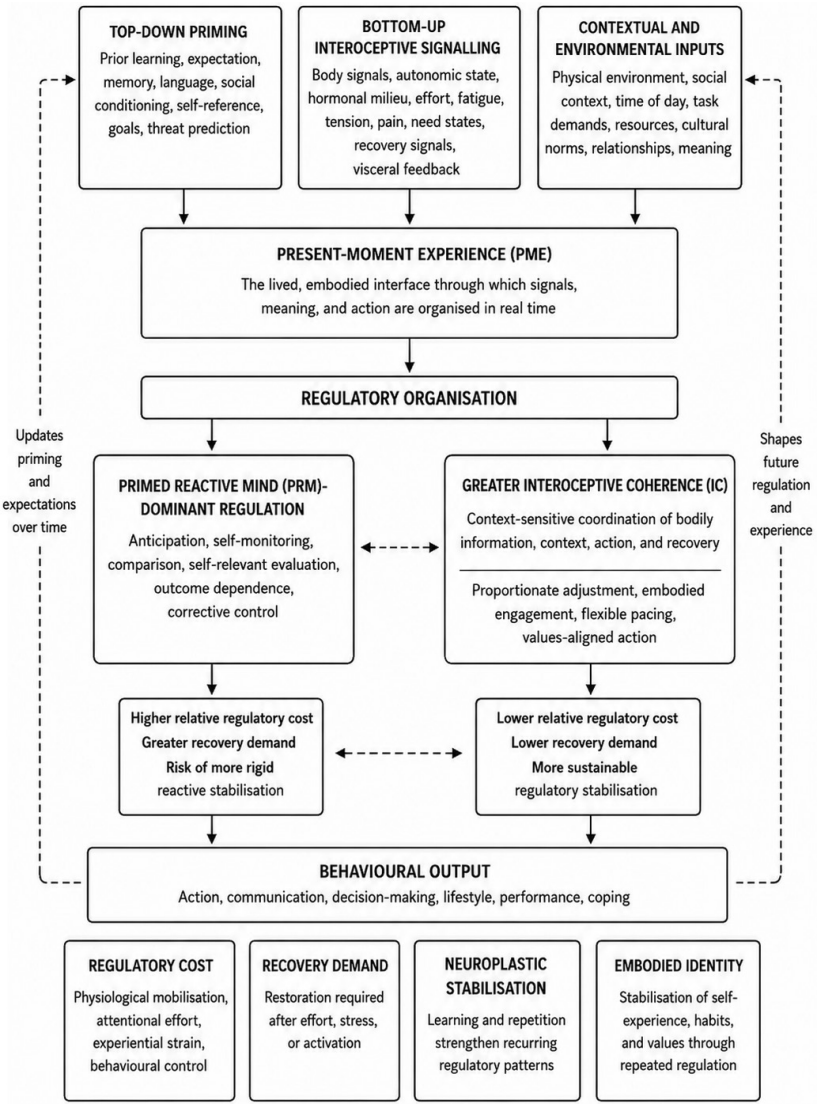

Figure 1 *Conceptual structure of the PIP Model*

Figure 1 represents behaviour and experience as emerging from interactions among prior learning, interoceptive and exteroceptive information, bodily state, and context. PME denotes the lived field within

which these processes become available for meaning and action. Regulatory organisation may become more PRM-dominant or demonstrate greater IC depending on how prediction, bodily information, attention, and context are coordinated. RE concerns the resulting relationship among function, mobilisation, adjustment, recovery, and future capacity. Repeated patterns may contribute to neuroplastic stabilisation and embodied identity, while outcomes and recovery influence later prediction and regulation. The figure is hypothesis-generating and does not represent a validated causal sequence.

The model has four principal aims. Conceptually, it distinguishes behavioural content from regulatory process. Explanatorily, it examines why knowledge, motivation, intention, or external monitoring may fail to produce sustainable change. Integratively, it connects selected findings from interoception, allostasis, predictive processing, autonomic regulation, stress physiology, motivation, behaviour change, embodiment, and learning. Translationally, it identifies candidate methods through which regulatory organisation may be observed, modified, and tested.

The framework may be relevant to health behaviour, rehabilitation, performance, stress, recovery, lifestyle, and identity formation, but it does not replace social, cultural, developmental, environmental, or clinical explanations. It does not imply that all behavioural difficulties necessarily arise from the regulatory processes described by the PIP Model. High regulatory cost may also reflect illness, disability, deprivation, unsafe environments, caregiving demands, or other unavoidable constraints. The model also does not claim that its constructs have been validated as a unified theory. Existing research on interoception, allostasis, affect, and mind–body interventions supports the broader plausibility of integrating bodily regulation and behaviour but does not directly validate the PIP Model (Lazzarelli et al., 2024; Santamaría-García et al., 2025). The framework should be refined or rejected

where its constructs fail to demonstrate reliable measurement, discriminant validity, or incremental explanatory value. Its central claim is intentionally limited: sustainable change may depend not only on what people do, but also on the regulatory organisation through which behaviour is produced, experienced, adjusted, repeated, and followed by recovery.

1.6 Structure of the book

The book develops the PIP Model from biological foundations through regulatory constructs and applied domains to measurement, intervention, and empirical testing.

Chapters 2–4 establish the principal scientific foundations. Chapter 2 examines homeostasis, allostasis, biological cost, and recovery demand. Chapter 3 develops interoception as a multilevel process contributing to affect, effort, decision-making, and behavioural adjustment. Chapter 4 considers predictive processing, prior learning, prediction error, and self-relevant interpretation as mechanisms shaping perception and action.

Chapters 5–8 define the core regulatory constructs. Chapter 5 introduces the Primed Reactive Mind and examines its architecture, short-term utility, potential cost, and learned stabilisation. Chapter 6 develops Present-Moment Experience as the lived interface through which bodily state, attention, memory, anticipation, meaning, and action are organised. Chapter 7 introduces Interoceptive Coherence as a proposed quality of coordination among bodily information, context, behaviour, and recovery. Chapter 8 defines Regulatory Efficiency and examines proportionate mobilisation, avoidable cost, flexibility, recovery, future capacity, regulatory debt, and the Regulatory Rebound Effect.

Chapters 9 and 10 address the self and regulatory dualities. Chapter 9 examines the minimal and autobiographical self, self-reference, embodied identity, and distributed neural systems involved in self-related processing. Chapter 10 considers tensions between minimal and autobiographical self, ego and embodied identity, goal and path, motivation and cost, and control and context-sensitive coordination.

Chapters 11–16 apply the framework to motivation, physical activity, stress, lifestyle, obesity, and technology. These chapters examine reward, relief, avoidance, movement regulation, recovery, mental health, sustainable daily behaviour, stigma, digital feedback, social comparison, and external monitoring. Dopaminergic pathways are treated as one component within a broader allostatic–interoceptive system rather than as a complete explanation of motivation.

Chapters 17–20 address operationalisation and testing. Chapter 17 considers self-report, experience sampling, interoceptive measures, heart-rate variability, sleep, recovery dynamics, effort, behavioural indicators, and experimental tasks. Chapter 18 presents candidate interventions while distinguishing theoretical proposals from established evidence of effectiveness. Chapter 19 outlines testable predictions, study designs, methodological constraints, and falsification criteria. Chapter 20 integrates the framework and considers its possible contribution to a science of embodied regulation.

The book therefore moves from foundational mechanisms to constructs, applications, measurement, intervention, and empirical evaluation. Its purpose is to present the PIP Model as a scientifically cautious and testable framework rather than a completed or comprehensive theory of human behaviour.

Chapter 2

Homeostasis, Allostasis, and the Cost of Adaptation

Human life depends on continuous regulation. The organism must preserve internal viability while responding to changing bodily, environmental, and social conditions. Temperature, blood pressure, glucose availability, oxygenation, hydration, acid–base balance, immune activity, inflammation, sleep–wake organisation, and autonomic state are maintained through coordinated neural, endocrine, immune, metabolic, and behavioural processes in interaction with environmental conditions.

This chapter establishes the biological foundation of the PIP Model. Every behaviour is enacted by an organism that must allocate resources, anticipate demand, maintain internal conditions, and recover after mobilisation. Behaviour therefore places regulatory demands on the organism and may incur biological and psychological costs whose magnitude and consequences depend on current capacity, context, prior load, and recovery.

Homeostasis and allostasis provide the principal physiological concepts for this analysis. Homeostasis concerns the regulation of internal variables within viable ranges and is classically associated with Cannon's account of organised physiological stability (Cannon, 1932). Allostasis extends this account by emphasising anticipatory and context-sensitive adjustment. Sterling (2012) described allostasis as predictive regulation through which biological systems prepare for expected requirements rather than responding only after substantial deviation has occurred. Adaptation is neither passive nor cost-free.

Physical exertion, illness, cognitive demand, social evaluation, pain, emotional activation, and sleep loss may require coordinated multisystem mobilisation. When demand is temporary, proportionate, and followed by sufficient recovery, such mobilisation may support adaptation. When it is recurrent, prolonged, or insufficiently terminated, cumulative burden may contribute to allostatic load or overload.

Allostatic load refers to multisystem burden associated with repeated or prolonged adaptive demands. McEwen and Stellar (1993) described it as a possible longer-term cost of regulatory mechanisms that are protective in the short term. Subsequent evidence has associated higher allostatic load with adverse health outcomes and increased all-cause and cardiovascular mortality risk, while also demonstrating substantial methodological variation in its measurement (Guidi et al., 2021; Parker et al., 2022).

Within the PIP Model, these concepts provide a foundation for examining biological cost, recovery demand, and Regulatory Efficiency (RE). They do not establish that a particular psychological mode directly causes allostatic load. The more limited proposition is that regulatory organisation may influence the magnitude, duration, and recoverability of mobilisation required to produce behaviour.

2.1 Homeostasis as the baseline logic of organismic regulation

Homeostasis refers to an organism's capacity to maintain internal variables within ranges compatible with continued functioning despite ongoing change. Cannon's classical formulation emphasised that internal stability depends on organised regulatory processes that detect deviation, coordinate correction, and preserve the conditions necessary for life (Cannon, 1932).

Homeostatic regulation should not be understood as rigidity or return to a single invariant set point. Physiological variables fluctuate with time of day, activity, nutritional state, environmental conditions, illness, and development. Stability is therefore dynamic: the organism continually modifies its functioning while preventing deviations that would become incompatible with viability or effective action.

Homeostasis is consequently better understood as the organised management of change within viable boundaries than as physiological constancy. Neural and autonomic systems alter cardiovascular, respiratory, and visceral activity; endocrine processes redistribute energy and support longer-duration adjustments; immune mechanisms respond to injury and infection; metabolism supplies and stores resources; and behaviour modifies the organism's relationship with the environment. Eating, drinking, movement, rest, sleep, thermoregulatory behaviour, and social interaction can all contribute to maintaining or restoring internal conditions.

Behaviour is therefore both an outcome and a mechanism of homeostatic regulation. By changing activity, posture, location, food intake, social environment, exposure to stimulation, or opportunities for recovery, the organism can influence its internal state. This principle is relevant to the PIP Model because the regulatory meaning of behaviour is state-dependent. An externally similar action may impose different demands according to health, fatigue, pain, previous load, emotional state, and available recovery. Walking at a moderate pace may support regulation under ordinary conditions but require substantially greater cardiovascular, attentional, or affective effort during illness, sleep deprivation, injury, or heightened evaluative pressure. The same behaviour may therefore contribute to restoration in one context, represent manageable adaptive demand in another, and exceed available capacity in a third.