
Introduction: Grounding Self-Regulation in the Brain and Body

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Self-regulation is a process that allows organisms to guide their behavior in the pursuit of their goals—desired end states they are committed to. Self-regulation is also a vital capacity that allows people to master their thoughts, feelings, and actions and concerns a high number of psychological processes, ranging from executive cognitive functions like attention control to higher-order processes like affect regulation or conflict resolution. But what goes on within people's brains and bodies when they are engaged in self-regulation? Does the biological machinery contribute efficiently to self-regulation or does it rather set natural limits to it? Can it contribute to understanding why people sometimes fail in the pursuit of their action goals? And, perhaps most importantly, can we use our understanding of the biobehavioral foundations of self-regulation to

increase people's chances of succeeding at self-regulation? These are the central questions that led us, together with our colleagues, to create this volume.

1.1.1 The Origins of Self-Regulation Research

It might be said that self-regulation research began around the beginning of the twentieth century with German will psychologists who investigated how people form intentions and how they try to realize their goals (see Ach 1935). This promising beginning, however, was followed by decades of silence in which mechanistic models of human behavior, mostly rooted in behaviorism, dominated behavior research (see Cofer and Appley 1964). The first formal models of self-regulation, rooted in cognitive psychology, still followed the mechanistic tradition by proposing that the basic working principles of so-called intelligent machines might be applied to human behavior (Miller et al. 1960; Powers 1973). These models applied feedback loops according to the principles of cybernetics to explain how organisms pursue goals by comparing their current states with their desired end states and execute behavior in order to minimize the eventual discrepancies between both. Such cybernetic principles are still part of modern self-regulation theories (Baumeister et al. 1994; Carver and Scheier 1998).

Yet modern theories have gone beyond their mechanistic beginnings. In modern theories of

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self-regulation, the self is an active agent (rather than a machine) who strives for attaining self-set goals or to comply with behavioral standards the individual is committed to (see Bandura 2001). This agentic perspective on self-regulation was kick-started in social and personality psychology in the early 1970s. Rediscovering early ideas about symbolic interactionism, a pioneering work on self-awareness theory (Duval and Wicklund 1972), explained how and why people can regulate their behavior to comply with their personal standards. About the same time, work on self-control, focusing on how people apply self-regulatory strategies to cope with conflicts between their short-term impulses and long-term goals emerged in developmental psychology (Mischel and Ebbsen 1970). Simultaneously, the role of self-beliefs in coping with challenges became a hot topic in behavior research (Bandura 1977). This was followed by modern approaches to action control that considered both cognitive and affective processes (Carver and Scheier 1981, 1998), a revival of will psychology (Heckhausen and Gollwitzer 1987; Kuhl 1986), and a groundswell of research on self-control failure (Baumeister and Heatherton 1996; Hagger et al. 2010).

Over the decades, self-regulation has attracted a great deal of attention from behavioral researchers (see Vohs and Baumeister 2011, for a recent overview). The biological aspects of self-regulation have received so far much less empirical attention. This seems surprising given the tremendous impact that biological approaches have had on adjoining areas of psychology, such as psychophysiology (Cacioppo et al. 2007), the cognitive and affective neurosciences (Gazzaniga 2004; Panksepp 1998), and also evolutionary psychology (Schaller et al. 2013). Conceivably, self-regulation researchers have neglected biological processes because their focus on an active, agentic self seemed hard to reconcile with the reductionism that has been historically associated with biological approaches to psychology (Geen 1995)—though the application of cybernetic principles of machines to human behavior has been regarded as less problematic, as evident in action control research. However, more

modern work has made it clear that a focus on biological mechanisms is perfectly compatible with the existence of higher-order regulatory processes (Kuhl and Koole 2004; Ryan et al. 1997). Consequently, the time is ripe for researchers to address the biobehavioral foundations of self-regulation. With the present volume, we seek to catalyze this development and to close a gap in the psychological and physiological literature by making an integrative link between self-regulation and biological processes.

1.1.2 Self-Regulation and Biological Systems

This volume gives the first overview of contemporary research on biobehavioral processes involved in self-regulation. This is important for at least three reasons. The first reason is that a biological focus greatly enriches self-regulation theory, by grounding self-regulation in the workings of the body and brain. Popular notions of self-regulation have traditionally been dualistic, portraying self-regulation as the product of a detached mind that in some mysterious way makes contact with the body and its needs, drives, and habits. Although most self-regulation theorists reject such dualism, neglecting the fundamental biological nature of self-regulation creates the risk of enshrining a mind–body dualism in theories of self-regulation. Self-regulation unfolds within the living tissue of our biological organism. It is therefore vital for behavioral theorists to heed the fundamental embodied, biological nature of self-regulation.

Studying the biobehavioral foundations of self-regulation is not just a one-way street. Indeed, a second reason for studying this topic is that a focus on self-regulation greatly enriches the scope of biological theories. Especially during the first half of the twentieth century, biological approaches within psychology were characterized by strong deterministic tendencies, by seeking to reduce the complexity of human behavior to simple drives or stimulus–response learning (see Cofer and Appley 1964). Fortunately, biological psychology has come a long way since

then. Theories in social, cognitive, and affective neuroscience have become increasingly attuned to the complex, multilayered systems that are involved in behavioral regulation (e.g., Gazzaniga 2004; Panksepp 1998). Importantly, modern theories allow for higher-level behavioral systems and interplay between different levels of control (e.g., Kuhl and Koole 2004). Behavioral research on self-regulation can inform and constrain these theories, creating a mutually beneficial dialogue between biological and behavioral researchers—as evident in several chapters of this book and especially in this book section that presents integrative perspectives.

Beyond addressing the basic question on how organisms can attain self-set goals, understanding the biobehavioral foundations of self-regulation has important implications for real-life problems. Self-regulatory success is associated with better health, achievement, and interpersonal relationships. Self-regulatory failure is associated with overeating, impulsive spending, drug abuse, delinquency, and other forms of misbehavior (Baumeister et al. 1994). This leads to the third reason, why considering brain and body processes in self-regulation promises important progress: Improving scientific insight into the biological aspects of self-regulation is likely to point to new ways for enhancing self-regulatory success while reducing self-regulatory failure.

1.1.3 Organization of This Book

As evident in this volume's 25 chapters, researchers have developed sophisticated models of biological processes in self-regulation in recent years. These approaches have developed from many different perspectives and subdisciplines. As a result, they are quite heterogeneous and involve many different physiological systems. Some approaches focus on the central nervous system, others focus on the peripheral/autonomic nervous system, and still others focus on the interaction of both. For instance, some models have addressed neurobiological processes, others hormonal influences, yet others cardiovascular processes, and so on. This heterogeneity is

expectable and probably the result of the complex, multifaceted nature of self-regulation. At the same time, the staggering complexity of the biology of self-regulation has made it important to allow different approaches to interface with each other and to facilitate mutual exchange of insights and ideas.

This volume starts with a foreword by Robert Wicklund who puts the original ideas about the self as the active agent and the importance of self-awareness in self-regulation in the broader context of the contemporary research focusing on biobehavioral processes presented in this book. The remainder of the volume is organized into five parts. The stage is set in Part I with five chapters on basic and integrative perspectives on biobehavioral aspects of self-regulation. The opening chapter provides an overview of the development of self-regulation research, covering the way forward from early cybernetic models to modern neuroscientific perspectives (Carver, Johnson, Joorman, and Scheier: "An evolving view of the structure of self-regulation"). The subsequent chapters focus on phylogenetic aspects and the evolutionary advantage of the development of self-regulation systems (Del Giudice: "Self-regulation in an evolutionary perspective") and the neural mechanisms involved in efficient self-control and self-control failure (Lopez, Vohs, Wagner, Heatherton: "Self-regulatory strength: neural mechanisms and implications for training"). This is followed by a chapter on muscle physiology and energetic processes that discusses the question if a muscle is a suitable metaphor for explaining self-control strength and self-control failure (Richter and Stanek: "The muscle metaphor in self-regulation in the light of current theorizing on muscle physiology"). The first section of this volume ends with a new perspective on protective inhibition in self-regulation and related adjustments in the neuroendocrine system (Tops, Schlinkert, Tjew A Sin, Samur, and Koole: "Protective inhibition of self-regulation and motivation—extending a classic Pavlovian principle to social and personality functioning"). Together, these contributions give an overview of the basic biobehavioral perspectives on self-regulation.

Part II of this volume includes four chapters focusing on the interaction of the affective and cognitive systems in self-regulation and related physiological processes. The first two of these chapters present new perspectives on affective influences on cognitive control (van Steenbergen: “Affective modulation of cognitive control—a biobehavioral perspective”) and error monitoring (Aarts and Pourtois: “Error monitoring under negative affect—a window into maladaptive self-regulation processes”). These are followed by a chapter on pupillometry, memory, and cognitive control (Papesh and Goldinger: “External signals of metacognitive control”) and another one that treats neural aspects of attention strategies in self-regulation (van Dillen and Papies: “From distraction to mindfulness—psychological and neural mechanisms of attention strategies in self-regulation”). Together, the chapters in this section provide an up-to-date overview of the affective influences on cognitive processes that are fundamental aspects of self-regulation.

Part III focuses on processes in the central nervous system in self-regulation. This section starts with two chapters that highlight central motivational processes that are important for self-regulation: The neuroscience of the reward system (Pessiglione and Lebreton: “From the reward circuit to the valuation system—how the brain motivates behavior”) and motivational orientations (Harmon Jones and Harmon Jones: “Neural foundations of motivational orientations”). This is followed by a neuroscientific model for the self-regulation of emotion and motivation (Livingston, Kahn, and Berkman: “Motus moderari—a neuroscience-informed model for self-regulation of emotion and motivation”) and a chapter dealing with the neural processes involved in self-insight (Beer and Flagan: “More than the medial prefrontal cortex (MPFC)—new advances in understanding the neural foundations of self-insight”). This part ends with a chapter presenting a neuroscientific perspective on social decision making (Knoch and Nash: “Self-regulation in social decision making—a neurobiological perspective”). Taken together, this section provides an overview of recent insights in the implication of the central nervous system

in important subprocesses that are involved in the self-regulation process and that are necessary for effective self-regulation.

Part IV presents six chapters dealing with the self-regulation of effort, i.e., resource mobilization for setting self-regulation processes into action. The section starts with the presentation of new insights in how the central and autonomic nervous systems interact in the mobilization of mental effort with links to health and disease (Radulescu, Nagai, and Critchley: “Mental effort—brain and autonomic correlates in health and disease”) and on the neural mechanisms involved in effort perception during physical tasks (de Morree and Marcora: “Psychobiology of perceived effort during physical tasks”). Next, there is a set of four chapters focusing on the autonomic nervous system and highlighting the role of the cardiovascular responses in self-regulation. The first chapter of these presents a new perspective on bounded automaticity in effort mobilization (Gendolla and Silvestrini: “Bounded effort automaticity—a drama in four parts”). This is followed by chapters dealing with cardiovascular responses in behavior restraint and self-control (Wright and Agtarap: “The intensity of behavioral restraint—determinants and cardiovascular correlates”), the role of self-focused attention in effort mobilization (Silvia: “How self-focused attention affects effort-related cardiovascular activity”), and future projections of the self and energization (Sevincer and Oettingen: “Future thought and the self-regulation of energization”). In summary, this section provides an overview of new insights in how the central and autonomic nervous systems contribute to the self-regulation of resource mobilization.

Finally, Part V presents five chapters dealing with problems in self-regulation and how these develop. This section starts with a chapter focusing on depression’s impact on resource mobilization (Brinkmann and Franzen: “Depression and self-regulation—a motivational analysis and insights from effort-related cardiovascular reactivity”). This is followed by an ontogenetic perspective discussing perinatal developmental aspects of self-regulation (Henrichs and Van den Bergh: “Perinatal developmental origins of

self-regulation”). Two further contributions deal with the biobehavioral mechanisms in self-regulation by rumination (Koster, Fang, and Marchetti: “Self-regulation through rumination—consequences and mechanisms”) and the impact of self-esteem on selective attention (Pruessner and Baldwin: “Biological aspects of self-esteem and attentional bias”). This section ends with a chapter discussing the interaction of the body–mind system considering central and autonomic nervous system processes and implications for psychopathology (Bernstein: “A basic and applied model of the body–mind system”).

1.1.4 Concluding Thoughts

As we stated at the outset, we have edited this volume to fill a gap in the literature dealing with understanding the processes underlying human behavior—a state-of-the-art overview of approaches to the role of the body and biobehavioral processes in self-regulation. We have done so by taking a diversity approach. One aspect of this diversity concerns the consideration of different physiological systems involved in self-regulation. Rather than limiting the overview to one system, we have included approaches focusing on the central nervous system, on the autonomic/peripheral nervous system, and on the interaction between both. We did so to capture multiple perspectives in current biobehavioral research. Another diversity aspect concerns the variety of self-regulation aspects and subprocesses this volume treats, reaching from physiological processes involved in fundamental aspects like attention and memory mechanisms to higher-order processes like the volitional control of desires and temptations in the pursuit of self-set goals. Finally, we have not limited this overview to fundamental theories and research findings, but have also considered applied problems like conditions of self-control failure and the link between self-regulation processes and pathologies.

Despite the large scope of this volume, we are aware that it does not provide an exhaustive summary of what researchers have learned about how self-regulation unfolds in the body. Many more

processes can and will be explored. We hope that this edited volume may serve as a starting point for readers to integrate what is known and to develop new ideas on how the body is involved in self-regulation to make the next important steps in better understanding human behavior.

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