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Recent Advances in Laboratory Assessment of Emotion Regulation

Saren H. Seeley^a, Emmanuel Garcia^b, and Douglas S. Mennin^{a,b}

^aHunter College, City University of New York, 695 Park Avenue, New York, NY 10065, USA.

^bThe Graduate Center, City University of New York, 365 5th Ave, New York, NY 10016, USA

Abstract

Over the past 15 years, the emotion regulation perspective has been widely integrated into theoretical and applied contexts in clinical psychology and beyond. Recent refinements to behavioral, subjective, psychophysiological and neuroimaging methods allow emotion regulation to be captured and assessed in the laboratory with greater precision. Technological advances enabling investigators to leverage information from multiple modalities are increasingly accessible, and as such, will further efforts to generate testable hypotheses about specific mechanisms implicated in emotion regulation and difficulties therein. In combination with theory-driven design, progressively sophisticated methods for laboratory assessment have potential to further emotion regulation as both a valid scientific construct and a useful paradigm for human emotion and behavior that has applicability to both clinical and non-clinical contexts.

Emotion regulation – or the ability to effectively manage emotions as they arise during the course of daily living – promotes adaptation and supports overall well-being. Conversely, poorer regulation carries consequences for both physical and psychosocial health [1,2]. Deficits in emotion regulation have been implicated as a risk or maintenance factor in anxiety and mood disorders, eating disorders, substance abuse, borderline personality disorder and autism spectrum disorders, among others [3,4]. Moreover, there is growing evidence that treatment for these conditions can be enhanced by targeting these deficits [5]. Gross's process model of emotion regulation, [1] which organizes strategies according to the location of their impact on emotions as they are generated, has had enormous influence on (as well as support from) the extant body of psychological literature [6]. Yet as a clearly-defined scientific construct, emotion regulation has been somewhat slower to gain traction, due in part to challenges in assessment [3]. Contextual and individual differences have lately been recognized as important moderators of emotion regulation's utility and efficacy in a given situation, casting doubt on the practice of conceptualizing strategies as simply "adaptive" or "maladaptive" [6,7*]. Similarly, research-based psychiatry and clinical psychology increasingly favor a dimensional view of psychological functioning that spans multiple 'units of analysis' across multiple domains (e.g., the National Institute of Mental Health Research Domain Criteria [RDoC]) [8]. Such considerations bring new challenges

and opportunities as affective science increasingly incorporates an emotion regulation perspective into theoretical, experimental, assessment, and intervention contexts [9]. In this brief review, we illustrate how current and future investigations within the lab may promote emotion regulation as an increasingly viable scientific construct [3]. Laboratory research that draws upon advances in theory and methods for capturing behavioral, physiological and subjective processes in the experimental setting will play a major role in current efforts to move from a more general view of emotion regulation toward greater conceptual validity, clarity and specificity [9].

Behavioral Assessment

Emotions promote survival as they guide how we respond to our environment. Given that emotion regulation is instrumental in experiential learning and goal-directed behavior, the influence of regulation on behavior (and vice versa) is a crucial consideration. Observable behavior, such as making risky choices in a gambling task, pulling or pushing a joystick to move stimuli towards or away from oneself, slowed reaction times on trials with conflicting emotional information, or duration of persistence on an impossible task, can serve as an objective measure of relevant constructs such as decision-making, motivation to approach or avoid, emotional conflict adaptation, or one's ability to withstand aversive internal states. Behavioral measures may complement self-report [10,11], distinguish disorder-specific deficits [10,12] or link constructs to candidate genetic polymorphisms (e.g., distress tolerance and SLC6A4 and COMT Val158Met [rs4680] alleles) [13]. Some examples of tasks commonly used in emotion regulation research include mirror tracing [e.g., 11], emotional Stroop [e.g., 12], and fear conditioning [e.g., 14]. One criticism leveled at behavioral paradigms is that some may not possess adequate clinical relevance or explanatory power [5,14]. For example, classic fear conditioning paradigms (in which an organism learns to predict threat) employ simple, unambiguous stimuli and measure overt behavioral expressions of fear. Thus they may be ill-suited to distinguish fear learning as an adaptive phenomenon for survival, versus the dysfunctional fear learning seen in pathological anxiety [14, 15]. However, this criticism may be addressed by theory-driven modifications to existing paradigms. In the example of fear conditioning, incorporating ambiguous stimuli and measuring implicit behavioral indicators of fear (such as avoidance) should better enable dysfunctional fear learning to emerge in order to clarify how conditioned fear is acquired, expressed and regulated in anxiety pathogenesis [15]. Additionally, as Aldao and Christensen [16] have recently suggested, we know relatively little about the mechanisms by which various emotion regulation strategies influence motivated behavior – in particular, how strategies produce effects on behavior which may facilitate or prevent individuals from acting in accordance with long-term goals and values. In order to look beyond short-term effects of regulation on behavior [5, 16], some studies have adopted sequential (i.e., assessing how performance on one task impacts performance on a subsequent task) [17] or longitudinal [18*,19] designs.. Longitudinal designs can also help to establish test-retest reliability for behavioral measures [20*]. Reliable, valid methods to assess behavior will be important for new taxonomical approaches such as RDoC, in which “behavior” is one of eight units of analysis [8].

Neuroimaging

Although numerous methods exist for examining the structure and function of neural systems involved in emotion, we focus here on one of the most widely used – functional magnetic resonance imaging (fMRI). While the recent decade has seen sizeable gains in understanding how regulation modulates emotion-related activity in the amygdala, prefrontal cortex, and other regions of interest [21], the focus of current fMRI studies is now frequently the dynamic coupling (or *functional connectivity*) between distributed brain networks involved in aspects of cognition, emotion and motivation that shape how we experience our world [22], rather than on specific individual areas [23]. A systems-neuroscience approach that links regulatory dysfunction to activity in various large-scale brain networks may help generate testable hypotheses about specific mechanisms of emotion regulation [20*,22,24], aided by new analytic methods to compare connectivity across multiple experimental contexts [25]. Some current directions include prospective or longitudinal designs, wherein participants undergo multiple scan sessions – for example, to evaluate how effects of reappraisal training change over time [19], or to compare intraindividual changes across different affective states (e.g., comparing implicit emotion regulation in the same participant during bipolar hypomania, depression and euthymia) [18*]. Because traditional emotion regulation paradigms have involved standardized stimuli (e.g., nomothetic emotional images or videos) and instructions (e.g., “reappraise” or “suppress”), there is growing interest in using fMRI to explore how neural bases of regulation may vary as a function of stimulus intensity [26*] or when individuals are allowed to select how and when to regulate emotions in the absence of explicit directions [27].

Electroencephalography

Electroencephalography (EEG) measures the power and lateralization of electrocortical activity, using electrodes placed on the surface of the scalp. Various EEG frequencies are sensitive to spontaneous processes [28] or instrumental goals (i.e., increase or decrease) [29,30] in emotion regulation. Certain frequency bands are also sensitive to emotional processing. For example, oscillatory activity in the theta band can clarify how strategies intervening at different points during emotion generation have divergent influence on how emotional stimuli are processed. This insight can help explain how strategies such as distraction versus reappraisal appear to carry different consequences for affective adaptation, despite producing comparable subjective outcomes (“*How do I feel in this moment?*”) [31]. One recent area of interest is the relationship between EEG oscillations and functional connectivity of neural networks involved in regulating emotions [32], given that EEG is well-tolerated by participants and can be used in more versatile settings. EEG may therefore yield useful information about brain network activity from larger samples and in settings when fMRI is either impractical or prohibitively costly. However, acquiring data in both modalities (i.e., “combined EEG-fMRI” [33]) holds promise to better capture implicit and explicit processes in emotion regulation. The ability to integrate multiple streams of information is integral to processing [34] as well as regulating emotions, as it is rare that evocative situations and events present themselves in only one sensory modality. EEG-fMRI is well-suited to provide insight into complex spatial and temporal dynamics, including how individuals integrate multiple simultaneous sources of information. Optimal regulation

involves selecting a strategy that is not only effective, but appropriate to the given environmental context. EEG-fMRI may facilitate the use of complex stimuli in emotion regulation research, given its potential to parse the temporal and spatial pathways involved in crossmodal sensory integration in the brain [33].

Event-Related Potentials

Event-related potentials (ERPs) are thought to reflect synchronous electrocortical activity time-locked to an event (e.g., stimulus onset) [35]. Their millisecond resolution make ERPs a well-suited approach to distinguish short-order processes in regulation, such as delineating motivational from regulatory deficits [36]. Two of the ERP components used extensively in emotion regulation research are the late positive potential (LPP; thought to reflect processing of emotional stimuli) and error-related negativity (ERN; thought to reflect performance monitoring) [35,36]. Because both the LPP and ERN have shown potential as candidate biomarkers of psychopathology [37], efforts to establish their psychometric properties are underway [38]. In similar efforts to glean maximal utility from ERPs as a method, new guidelines for best practices in data collection and reporting aim to foster generalizability between labs [39]. Like EEG, ERP methods have the advantage of being relatively unobtrusive and affordable, even moreso with the advent of consumer-oriented or research-grade wireless systems. These systems can be used in or outside of the laboratory, either in experimental scenarios involving some degree of movement (e.g., interpersonal interaction), in ambulatory assessment [40] or with populations who may have difficulty tolerating extensive psychophysiological set-ups [41].

Peripheral Psychophysiology

Psychophysiological research increasingly views the role of autonomic nervous system (ANS) in emotion regulation in terms of its interactions with immune, neuroendocrine and central nervous system processes, as well as the impact of these interactive relationships on health [42]. Commonly-used measures such as heart rate variability (fluctuations in the time interval between heartbeats), electrodermal activity (skin conductance), electromyography (muscular activity, including the face), and pupillometry (pupil dilation) are often employed concurrently. One advantage of this multimodal assessment is the ability to capture state level variations that might not be apparent through a single physiological or subjective measure alone [43*]. As a particular physiological response (e.g., vagal withdrawal as evidenced by decreased heart rate variability) may exhibit relationships to numerous psychological phenomena and vice versa [42], techniques that allow researchers to manage and evaluate multiple channels of psychophysiological data collected in different modalities and on different time scales are increasingly essential [44]. With the advent of MRI-compatible equipment, the ability to integrate peripheral and central measures (e.g., impedance cardiography and fMRI) [45] can provide more detailed insight into the neurobiological bases of emotion and regulation [46*]. As with EEG, ambulatory systems (e.g., using smartphone technology or wireless sensors) can be used to capture psychophysiological dynamics in more naturalistic settings, or employed in the lab for a less restrictive set-up [41].

Subjective Measures

Self-report measures can arguably be confounded by traits such as emotional awareness which are themselves associated with better emotion regulation ability [4], and have been criticized for reflecting what people believe they do (or should do), rather than how people actually behave in a given context [10,47]. Ecological momentary assessment (EMA) prompts participants to periodically provide state ratings as they go about their daily lives [41]. EMA can inform lab-based investigations by providing insight into the phenomenology and the temporal dynamics of emotion regulation, including important variation that may be lost if individuals are asked only to report their emotions or manner of regulating in aggregate [48]. EMA studies suggest that people may use some of the most common strategies assessed in experimental paradigms relatively little, while using a greater number and variety of emotion regulation strategies than are typically assessed in studies [49*]. Finally, there is growing recognition of the importance of positive emotion in physical and psychological health [2]. While emotion regulation research has traditionally focused on how people manage negative emotions, measures of response to reward, or positive emotion regulation (e.g., savoring or dampening) are seeing more use [48,50].

Future Directions and Challenges

Emerging conceptualizations view emotion regulation as a dimensional process that encompasses multiple components on individual, situational, instrumental and other levels (see [7**,9]). This view has driven emotion regulation researchers to develop new techniques for laboratory assessment, and to refine or incorporate existing methods in novel ways. Many of the advances reviewed here converge on the idea of making laboratory assessment more reliable, precise and ecologically and theoretically valid, and these aims are likely to underlie future progress in this area [9,14,7**]. For example, future investigations should consider that internally-mediated regulatory efforts (i.e., worry, rumination, or self-criticism) often occur in absence of a direct extrinsic stimulus or external target of regulation. In order to understand how dysfunctional distress may arise from conflicting emotions and motivations in complex forms of psychopathology (e.g., comorbid generalized anxiety disorder and major depression), it will be important to capture such efforts as both processes and outcomes in future work [7**,51]. Inductions designed to generate “top-down” emotions (evoked by the appraisal of a situation as being relevant to one’s goals and values, versus “bottom-up” emotions evoked by biologically-relevant stimuli) should provide insight into how emotions can arise and be regulated via internal representations [52*].

Measures (or combinations of measures) which are sensitive to state changes in such representations can also aid in understanding these processes. For example, in a recent study, cues which signaled participants to get ready to switch from rest to executing a task were associated with activation in the right anterior insula, an area involved in regulating autonomic activity and supporting externally-oriented attention and behavior [53]. Examining anticipation and other forms of ‘mental time travel’ may provide insight into how cognitive emotion regulation, including internally-mediated efforts, might influence physical [54] as well as psychological [51] health.. Similarly, despite a wealth of evidence

implicating emotion regulation in health-related decision-making, outcomes and behaviors [2], the vast majority of these studies have been correlational or cross-sectional in nature. It will be important for future investigations to be able to manipulate and capture state changes in hypothesized mechanisms (e.g., inflammation) in the lab [54] as well as to employ designs (e.g., longitudinal) which can demonstrate downstream effects of these mechanisms [16].

Finally, while space does not permit full discussion of the topic here¹, it goes without saying that meaningful research in emotion regulation necessarily relies upon effectively eliciting the desired emotion to be regulated. Future work may resolve a number of current challenges related to some of the induction techniques currently in use – for example, tasks which require participants to generate and interact with personally-relevant stimuli are more likely to be actively engaging and thus invoke motivational states, compared to passively viewing standardized videos and images - but are as of yet used far less frequently than the latter [7**]. Future research will also need to develop techniques for eliciting complex or mixed emotional/motivational states, as our reactions often involve experiencing several emotions concurrently or in rapid succession. The ability to skillfully navigate these states is a main feature of emotion regulation, and inability to do so may be a key factor in developing distress-related psychopathology [51]. Likewise, studies to date have typically paid more attention to multimodal *output* (i.e., responses in subjective, behavioral and physiological domains) than *input* (i.e., characteristics of stimuli) despite the fact that we generally receive information from the world around us from more than one sensory modality [7**,34]. For example, one recent study found that startle reflex, LPP amplitude and threat stimuli (images of fearful facial expressions) were modulated by social anxiety in the presence of chemosensory stimuli – in this case, smelling the sweat of anxious individuals [55]. Methods such as combined EEG-fMRI that can capture both the time course and spatial pathways in how multiple sources of sensory information are organized [33] in service of regulation have potential to aid ecological validity. However, in order to maximize the utility of such research, there is a need to standardize procedures for collection, analysis and publication of data so that findings from different work groups may be compared or combined [3,39].

Conclusions

We have reviewed how recent empirical work has sought to gain conceptual clarity and precision through methods to address subjective, behavioral, and psychophysiological sequelae of emotion regulation [3,9]. While a number of challenges remain, the expansion of emotion regulation and affect science perspectives over the past several years owes much to refined methods to elicit and capture emotional states and regulatory efforts in the laboratory. As emotion regulation researchers increasingly consider the role of individual and contextual differences in how people choose to regulate their emotions; why, when and how their attempts succeed or fail, and the short- and long-term effects of their efforts [7**],

¹For a more complete discussion, see the recently-published review chapter by Quigley, Lindquist, and Barrett (2014) in the *Handbook of Research Methods in Personality and Social Psychology* or Allen and Coan's (2007) *Handbook of Emotion Elicitation and Assessment*.

current and future work is likely to draw upon numerous practical (i.e., data collection and analysis) and theoretical (i.e., method selection and experimental design) advances. Valid, reliable and specific techniques that can delineate mechanisms of emotion regulation will be progressively central to translational efforts, generating empirical findings to be mapped onto the provisional RDoC framework [8] and ultimately, used to target assessment, prevention, and intervention efforts to meaningfully enhance the lives of individuals [3,4].

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