Toward a personalized science of emotion regulation

Bruce P. Doré, Jennifer A. Silvers, & Kevin N. Ochsner

Department of Psychology, Columbia University, New York, NY

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Abstract

The ability to successfully regulate emotion plays a key role in healthy development and the maintenance of psychological well-being. Although great strides have been made in understanding the nature of regulatory processes and the consequences of deploying them, a comprehensive understanding of emotion regulation that can specify what strategies are most beneficial for a given person in a given situation is still a far-off goal. In this review, we argue that moving toward this goal represents a central challenge for the future of the field. As an initial step, we propose a concrete framework that 1) explicitly considers emotion regulation as an interaction of person, situation, and strategy, 2) assumes that regulatory effects vary according to these factors, and 3) sets as a primary scientific goal the identification of person-, situation-, and strategy-based contingencies for successful emotion regulation. Guided by this framework, we review current questions facing the field, discuss examples of contextual variation in emotion regulation success, and offer practical suggestions for continued progress in this area.
Emotion regulation is central to emotional well-being and physical health. In the past 15 years, the literature exploring this ability has flourished, yielding a diverse body of research approaching the topic from multiple levels of analysis (Gross, 2015; Ochsner, Silvers, & Buhle, 2012). However, a key question for the science of emotion regulation has so far been little addressed: can we predict for particular people, in particular situations, which emotion regulation strategies will be most beneficial? Addressing this question is important both for constructing basic science models that accurately reflect the complexity of the natural world, and for translational research, which by its nature is deeply concerned with identifying appropriate interventions for individuals who suffer emotion dysregulation in specific situations or in response to particular cues (Silvers, Buhle, & Ochsner, 2014).

To date, work on emotion regulation has been constrained in scope such that it cannot fully address this question. Existing research has built a model of emotion regulation predominantly by studying a particular population (e.g., healthy young adults), a particular situation (e.g., normatively aversive films or images), via the use of particular strategies (e.g., reinterpreting the meaning of a film in order to feel less negative) (see Aldao, 2013; Gross, 2015). Limiting the variables at play when studying a phenomenon within the laboratory provides experimental control that is crucial for drawing inferences about whether it is possible for a variable to exert a causal effect. That said, the basic model that guides much contemporary emotion regulation research has now received strong support (Gross, 2015; Ochsner et al
2012; Webb, Miles, & Sheeran, 2012), and researchers are beginning to move beyond it to formulate the next iteration of emotion regulation research.

As we see it, the most pressing goal for the future of this field will be to extend and test the boundaries of the basic model by estimating variation in core emotional and regulatory processes, with an eye towards identifying the conditions that support successful regulation of emotion. In this article we consider how the field can move toward addressing these issues. In doing so, our aim is not to identify precisely which studies need to be conducted in the short-term, but rather to sketch out the form that such studies may take in the medium- and long-term. As detailed below, we argue for a theoretical approach that prioritizes the estimation of person-, situation-, and strategy-based variation in emotion regulation success and leverages novel methods for data collection and analysis in service of this overarching goal.

**EMOTION REGULATION AS A PERSON × SITUATION × STRATEGY INTERACTION**

Theories in social psychology have long emphasized the interaction of persons and their social context, beginning with Kurt Lewin’s field theory (1951), which posited that person and situation factors interact to produce behavior. One person by situation framework that been particularly influential framework is Mischel and Shoda’s cognitive-affective processing system (CAPS) model (1998). According to the CAPS model, situations in the world elicit patterns of cognitive-affective processing units and these units combine to generate behavior. Another influential framework, regulatory fit theory, focuses on the interaction between person and strategy, proposing that people can self-regulate most effectively when
they pursue goals in a manner that fits (i.e., is consistent) with their chronic ways of regulating (Higgins, 2005).

Although emotion regulation is inherently an interaction of person, situation, and strategy factors, past research has focused more on main effects of each of these influences (e.g., benefits of a particular strategy as compared to others), and dominant models of emotion regulation have not foregrounded such interactions (see Aldao, 2013; Koole & Veenstra, 2015). Here we argue that explicitly modeling emotion regulation as a person by situation by strategy interaction can provide direction for the growth of this field. A long-term goal of such an approach is the development of a family of models that can be applied to describe and explain the tremendous variability seen in instances of emotion regulation across different people, evocative situations, and regulatory strategies.

**Emotion Generation as a Person × Situation Interaction**

Before discussing regulation, it is useful to consider models of emotion generation, and how they set the stage for our approach to emotion regulation. Fundamentally, an emotion represents the interaction of a person (or another organism) with an emotionally evocative situation. Consequently, an emotion is more than the sum of its parts: that is, person and situation factors exert both additive (i.e., main effect) and interactive influences on emotion generation.

In terms of main effects, people may vary in emotional reactivity (the intensity of their initial emotional reactions to the world) on a continuum from unreactive to hyper-reactive. Likewise, situations might vary in their potential to
evoke intense responses, from mildly evocative (a shoelace becomes untied while walking) to extremely intense (you trip on the shoelace into oncoming traffic).

However, in contemporary theory, emotion generation is driven by an appraisal of the relevance of a situation to goals/wants/needs, and variability in emotional responding is driven by the interaction of situational features and appraisal tendencies (Barrett et al., 2007; Ellsworth & Scherer, 2003; Lazarus, 1993). Simply put, where certain people are emotionally sensitive to particular situational dimensions, others are moved less, differently, or not at all (consider how an expert antique appraiser versus layperson approaches an estate sale). Thus, the emotion generation process reflects a particular form of person by situation interaction brought about via the operation of appraisal systems that are driven by past experiences as well as current and chronic goals and knowledge.

**Emotion Regulation as a Person × Situation × Strategy Interaction**

Following this logic, if emotion generation is a person-situation interaction, then emotion regulation brings a third component into play – the regulation strategy. Emotion regulation entails encountering an evocative situation and regulating one’s response to it using a particular strategy. An instance of regulation is successful, in the short term, if it brings about a desired emotional outcome and, more broadly, if it brings about longer-term well-being (McRae, 2013; Tamir, 2009). In addition to person and situation variables, whether an attempt to regulate succeeds depends on characteristics of the strategy, which may have additive impact or may interact with person and situation influences. A commonly cited example of a regulatory main effect concerns the difference between *reappraisal*, a
regulation strategy that involves reframing the meaning of an emotional stimulus and *expressive suppression*, a regulation strategy that involves limiting behavioral displays of emotion. Reappraisal is often seen as the preferred strategy because (when used to down-regulate emotion) it can diminish behavioral, experiential and autonomic measures of emotional response (Gross & Levenson, 1993). By contrast, expressive suppression impacts behavior, and can also impact experience (albeit to lesser extent than reappraisal), but does so at the cost of increasing autonomic arousal and impairing memory (Davis, Senghas, & Ochsner, 2009; Davis et al., 2010; Richards & Gross, 2000).

This is where the importance of examining interactive as opposed to additive (i.e. main) effects in the domain of emotion regulation becomes clear. For example, the benefits of reappraisal may be attenuated or reversed for particular people, or in particular situations. Specifically, when a distressing situation is controllable, it may be wise to change objective features of the situation (i.e., use a situation modification strategy) rather than use reappraisal to change the way the situation is interpreted. Supporting this idea, a recent study found that higher reappraisal ability predicted lower depressive symptoms for participants experiencing uncontrollable stressors, but, strikingly, actually predicted greater depressive symptoms for participants experiencing controllable stressors (Troy, Shallcross, & Mauss 2013). This pattern suggests that whether reappraisal is adaptive depends on the controllability of the situation it is being leveraged against, and raises the possibility that having high capacity to use reappraisal may lead people to apply it imprudently. Moreover, several studies suggest that the costs of expressive
suppression are diminished or reversed for people whose cultural background
values emotional restraint (Butler, Lee, & Gross, 2009; Soto et al., 2011).

In another example, a seminal line of research in self-regulation found that
children’s ability to delay gratification (i.e., to forgo a small immediate reward and
wait for a larger one) at about 4 years of age prospectively predicted important
outcomes later in life, like body mass in childhood (Francis & Sussman, 2009), SAT
scores in adolescence (Shoda, Mischel, & Peake, 1990), and drug use in adulthood
(Ayduk et al., 2000). Although the results of these studies are sometimes thought of
as evidence for main effects of stable self-control ability, careful assessment of the
relevant data shows that the predictive value of delay behavior is attenuated by a
host of other factors, including gender (Francis & Sussman, 2009; Shoda et al.,
1990), age (Francis & Sussman, 2009), tendency to anxiously expect rejection
(Ayduk et al., 2000), and whether, in the delay task, a cognitive strategy for waiting
was supplied or not (Shoda et al., 1990). Though little research has examined this
possibility, there must also be cases in which self-control capacities are leveraged
toward goals that are detrimental to overall well-being, like using drugs or
committing crime in order to gain a social reward (see Rawn & Vohs, 2011), or
avoiding the consumption of food in eating disorders (Steinglass et al., 2012).

Overall, this line of theorizing prompts the hypothesis that failure or success
in emotion regulation may be characterized as emerging not from a context-free
continuum of person-level regulatory ability but from a set of person by situation by
strategy interactions (e.g., Person A tends to succeed with strategy A in situation A
but fail with strategy A in situation B or strategy B in situation A).
THE PERSON BY SITUATION BY STRATEGY MODEL

Given the breadth of work in emotion regulation, it is crucial to organize findings within an overarching framework. Nearly two decades ago, James Gross developed a process model of emotion regulation that has been tremendously influential for the growth of this field (Gross, 1998a). Primarily, the process model of emotion regulation is a description of categories or groups of emotion regulation strategies -- situation selection, situation modification, attentional deployment, cognitive change, and response suppression -- that are organized by the temporal stage of the emotion generation process that they target.

More recently, Ochsner and Gross (2014) and Gross (2015) have proposed an extension to this model that delineates the role of nested valuation cycles in the generation and regulation of emotion. From this perspective, emotion regulation unfolds iteratively over time, but can be broken up into discrete temporal stages, including identification (of an opportunity to regulate emotion), selection (of a particular regulation strategy), and implementation (of a selected strategy) (see Gross 2015). Here, we build on these ideas by situating them within an overarching framework delineating 1) the factors (i.e. sources of variability) that comprise the person by situation by strategy context in which emotion regulation is embedded and 2) the manner in which these contextual factors influence discrete temporal stages of the emotion regulation process.

[Insert Figure 1 about here]

**1. Sources of variability in emotion regulation.** According to our model, the effects of the regulation strategies identified by Gross (1998a) depend on
measurable characteristics of the persons leveraging them and the situation(s) they are being leveraged against. That is, sources of variability in emotion regulation success consist of main effects of person, situation, and strategy, as well as their interactions.

In Figure 1, we provide examples of person, situation, and strategy factors that are likely to have additive and interactive influences on emotion regulation success, meant to be illustrative rather than comprehensive. Our current understanding suggests that the impact of a given variable, like age (a person variable), on emotion response channels will depend on the other variables (in this case, situation and strategy). Because our ultimate goal is to generalize our models to all people, across all emotional situations and all regulatory strategies, it is important to assess these variables comprehensively as a field, even though such an ambition is impossible for any particular study.

An example of a person by situation interaction is apparent in comparing reappraisal of aversive and appetitive stimuli in children. Recent work from our laboratory has revealed that children are more successful when reappraising appetitive food stimuli than when reappraising aversive social stimuli (Silvers et al., 2012; Silvers et al., 2014; Silvers et al., 2015). These findings have at least two possible explanations. One explanation is that developing neurobiology allows for prefrontal regulation of subcortical structures involved in generating appetitive responses before regulation of regions involved in generating aversive responses (see Fareri et al., in press; Gabard-Durnam et al., 2014). Another possible explanation is that that children have more experience interpreting food cues than
they do with negative social situations and this experience facilitates better regulation (i.e., children eat food every day of their lives but encounter negative social situations less frequently). These possibilities could be tested by examining whether repeated practice with reappraising aversive social cues improves children’s reappraisal ability. If practice makes children look more “adult-like” in their ability to reappraise, this would suggest that a lack of familiarity with regulating negative emotions underlies age effects rather than an absolute biological constraint.

[Insert Table 1A & B about here]

2. **Dynamics of person, situation, and strategy influences.** Building from the extended process model (Gross, 2015), we represent three distinct temporal stages where person, situation, and strategy variables may exert additive and interactive influence (Table 1A): first, when identifying an opportunity to regulate, second when selecting a particular regulation strategy, and third, when implementing a selected strategy. These three stages of emotion regulation form the columns of Table 1A, and the rows specify the kinds of person, situation, and strategy factors that can influence these stages. The first three rows consists of person, situation, and strategy main effects that that influence emotion regulation via the identification, selection, or implementation, collapsing across other variables. The next three rows consist of two-way interactions of these factors, including person by situation interactions (which specify situations that lend themselves to successful regulation for particular people), person by strategy interactions (which specify the strategies that “fit”, or work best for particular
people), and situation by strategy interactions (which specify the strategies that
“fit”, or work best for particular situations). Although most existing studies have
focused on main effects, in Table 1B we provide illustrative examples of studies that
have looked at main effects and interactions of person, situation, and strategy
factors (in black), as well as hypotheses for future research (in grey italics).

[Insert Table 2 about here]

**Measuring person, situation, and strategy-based variation**

In Table 2 we illustrate the design of three characteristic investigations of
emotion regulation that illustrate the impact of design choices on outcomes and
inference. In the first, Gross (1998b) held person and situation variables constant in
order to reveal a main effect difference between reappraisal and expressive
suppression (reappraisal evoked greater decrease in emotional response to a
disgusting film). In the second, Troy, Shallcross, and Mauss (2013) held strategy
constant and measured variability in person and situation factors to reveal a two-
way interaction effect (high reappraisal ability was helpful for uncontrollable
stressors but harmful for controllable stressors). In the third, across two studies,
Silvers and colleagues (2012, 2014) held strategy constant, and asked people of
different ages to reappraise both aversive or appetitive stimuli, revealing an
interaction-like pattern (relative to adults, children were impaired at reappraising
aversive but not appetitive stimuli). Studies that incorporate two-way interactions
of person and situation may inform whether it is advisable to recommend a strategy
(like reappraisal) for particular people in particular situations. Moreover, studies
that simultaneously model all three sources of variability can reveal three-way
interactions informing which strategies are particularly advisable (relative to other strategies) for certain people in certain situations.

**The Value of an Interactionist Approach to Emotion Regulation**

In considering and estimating the kinds of interactions in Table 1, we move from a science focused on describing population averages (i.e. behaviors and processes that are apparent when averaging across studied people and situations) to one focused on describing and understanding person-specific processes whose operation varies as a function of context. Just as approaches to *personalized medicine* focus on tailoring medical treatment to the characteristics, goals, and abilities of individuals by drawing on a knowledge base that is grounded in contextual dependencies (e.g., Hamburg & Collins, 2010), a *personalized science of emotion regulation* may be able to make better contact with regulatory attempts in real-world contexts, for both healthy and clinical populations.

Along with its potential value, this approach brings new compromises. In its extreme form, the interactionist approach entails shelving questions like, “Which regulation strategy is best?” in favor of a theoretical stance that assumes context-varying regulatory effects as a basic tenet and holds as a primary scientific goal the identification of the person, situation, and strategy contingencies for this variation (see Gross, 2015). In doing so, contributors to this field may avoid what Bonanno and Burton (2013) call “the fallacy of uniform efficacy” or what Gelman (2014) more generally refers to as “the presumption of constant effects” that can be implicit in traditional approaches to research design and analysis.

**BUILDING A KNOWLEDGE BASE THAT IS GROUNDED**
IN INTERACTIVE PROCESSES

Our overarching question for the remainder of this article is as such: how do we build a knowledge base that can shed light on the person by situation by strategy interactions that constitute emotion regulation? To address this question, we reflect on how the field generates knowledge about emotion regulation, review prior research that demonstrates or suggests important interaction effects, and offer suggestions for future progress.

Practical Directions

Scientific knowledge about emotion regulation comes from two sources – observation of emotion regulation in daily life and observation of emotion regulation in lab studies in which we manipulate and measure particular variables. In Figure 2, we schematize this knowledge generation process, highlighting reciprocal influences between these two sources of information and identifying sub-processes instantiated in particular kinds of empirical studies. With these reciprocal influences in mind, an interactionist approach to emotion regulation suggests three kinds of directions for future research.

[Insert Figure 2 about here – the knowledge generation cycle]

1. **Enrich lab paradigms by incorporating important person, situation, and strategy variables.** Important advances will come from modifications to lab paradigms that seek to incorporate variables that are inherent to emotion regulation but are not modeled in current lab tasks and paradigms. There are at least three kinds of variables that may be important but are currently understudied.
**Person-level variables.** A crucial direction for future work will be to quantify variability in emotion regulation *capacity* (i.e., strategy implementation) and *tendency* (i.e., identification and strategy selection) from person to person, and ask how much of this variability can be understood with reference to person-level variables like age, personality, and psychopathology. Capacity refers to what people are capable of doing to regulate their emotions, which has been studied by instructing participants how and when to use specific regulatory strategies (see Buhle et al., 2013; Webb, Miles, & Sheeran, 2012). Tendency refers to what people tend to do when allowed to choose whether and how to regulate, which has been studied by observing regulatory behaviors or asking participants to report on them (all in the absence of explicit instructions to regulate; see Gross & John, 2003; Moore, Zoellner, & Mollenholt, 2008; Aldao, Nolen-Hoeksema, & Schweizer, 2010).

The theoretical distinction between regulatory capacities and tendencies is inherently linked to the idea of person by situation interactions, in that regulatory tendencies are governed by situational contingencies that specify when particular strategic capacities are deployed.

The capacity versus tendency issue may be particularly relevant to questions about emotion regulation across the lifespan. For example, when children display less regulated emotional behavior than adults, this could be due to them being less inclined to less regulate, less capable of regulating, or both. Questionnaire and behavioral measures have revealed that individuals exhibit greater meta-cognitive awareness of regulatory strategies (Mischel & Mischel, 1983), greater tendency to use cognitive strategies (Garnefski, Legerstee, Kraaij, van den Kommer, & Teerds,
and greater emotion regulatory capacity on lab-based cognitive regulation paradigms (Silvers et al., 2012) from childhood to adolescence and adulthood. While little work has tested whether regulatory capacity and tendency co-develop or whether one informs the other, there is some evidence to suggest capacity can precede tendency. For example, work by Mischel and colleagues has revealed that children as young as 4 years can cognitively transform a tempting treat when instructed to do so and can wait longer for said treat when it is out of sight, yet children do not endorse such strategies as being useful until years later (Mischel & Mischel, 1983; Yates & Mischel, 1979; Moore, Mischel & Zeiss, 1976).

From young to older adulthood, a paradox has been noted: although there is decline in prefrontal regions and the cognitive abilities associated with them, older age is associated with reliable increases in positive emotion and well-being (Mather, 2012; Carstensen, 2011). A key question here is to what extent the ‘rosy glow’ of older age reflects changes in the changes in the capacity for particular regulatory strategies (i.e., strategy implementation), changes in the tendency to deploy them (i.e., identification and selection), or some combination of the two. Studies have begun to address this issue by examining two strategies in particular – attentional control and reappraisal. On the attention side, it appears that older adults have both spared capacity to redirect and/or control the focus of their attention to regulate their emotion, and may tend to spontaneously use this strategy to look away from unpleasant and towards pleasant stimuli (Mather, 2012; Tucker et al., 2012; Isaacowitz et al., 2006). On the reappraisal side, older adults might be more likely to
reappraise, but their capacity to do so effectively may depend on the specific goals they have when reappraising. Older adults show lesser ability to down-regulate negative emotion (e.g., Winecoff et al., 2011; Shiota & Levenson, 2009) but spared ability to enhance positive emotion via reappraisal (Shiota & Levenson, 2009). Together, these data suggest that whether older adults are successful or struggle when attempting to regulate may depend upon the strategy they deploy and their goals for regulation.

Beyond age, many other person-level variables may influence the success or failure of particular instances of emotion regulation, including gender (e.g., McRae et al., 2008), personality (e.g., Widiger, 2011; Meier et al., 2006; Wilkowski & Robinson, 2010), cultural background (e.g., Soto et al., 2011), and emotional awareness (e.g., Hill & Updegraff, 2012). Though less studied, people may also vary appreciably in their knowledge of, motivation for, and skill with emotion regulation.

**Situation-level variables.** In addition to person-level variability, it's important to identify variability along situational dimensions, and to ask what consequences this variability has for our general understanding of regulatory processes. While ecological momentary assessment (EMA) methods are well-suited to tracking people as they navigate different situations, many important situational variables can also be profitably modeled in lab paradigms, enabling identification of basic brain mechanisms that track situational change.

One situational variable that may be particularly important is stress level at the time of an emotional encounter. Acute exposure to stress is known to impact prefrontal cortex function and to disrupt performance in cognitive control tasks.
(Alexander et al., 2007; Arnsten, 2009), and a recent investigation showed a pattern of results consistent with the idea that acute stress impairs participants’ ability to deploy cognitive resources to reappraise aversive stimuli (Raio et al., 2013). While this result fits with those of an imaging study showing that social stress impairs prefrontal function and a measure of cognitive control (van Ast et al., 2014) that may depend upon some of the same mechanisms as reappraisal (Ochsner et al., 2012), it didn’t make clear whether stress increased the strength of emotional reactions, impaired regulatory ability, or some combination of both. Disentangling these possibilities will be a key direction for future research.

Another important but understudied situational factor is whether the evocative stimulus will be encountered only once, or if it will be re-encountered in the future. This variable is relevant for understanding whether a given regulation strategy can have durable effects (e.g., Denny et al., 2015), and whether the ability to deploy a given regulation strategy effectively can be trained via practice (e.g., Denny & Ochsner, 2014). Though only a handful of studies have examined these questions, the existing literature indicates that reappraisal can lead to decreases in brain measures of emotional responding across both short-term (e.g., 30 minutes) and longer-term (e.g., one week) delays (Denny et al., 2015; Erk et al., 2010; Silvers et al., 2014). Because strategies like distraction and expressive suppression are unlikely to cause long-term change in affective representations this suggests that reappraisal is preferred for situations where lasting change is desired (see Kross & Ayduk, 2008; Sheppes et al., 2014; Denny et al., 2015).
Among other fundamental situational differences that could prove important are the valence (e.g., Quoidbach et al., 2010), intensity (e.g., Sheppes, Catran, & Meiran, 2009), and category of emotion elicited (e.g., Rivers, Brackett, Katulak, & Salovey, 2007), as well as the social content (e.g., Silvers et al., 2012), controllability (e.g., Troy, Shallcross, & Mauss, 2013), and time and distance from the evocative event (e.g., Dore, Ort, Braverman, & Ochsner, 2015).

**Strategy-level variables.** A third crucial source of variability is the regulation strategy that is applied to regulate the emotional response. As noted earlier, one well-developed body of work has contrasted expressive suppression, which targets the behavioral display of emotion, to reappraisal, which targets evaluations of the meaning of negative stimuli. Although between-strategy differences are clearly important, it may be just as important to consider within-strategy differences in the tactics that are used in the service of a given strategy. For example, within the context of reappraising negative experiences, we can distinguish positive reappraisal tactics, used to enhance positive feelings by finding positive aspects or implications of negative situations, and neutralizing reappraisal tactics, used to dampen negative feelings by focusing on neutral aspects or implications of negative situations (McRae, Ciesielski, & Gross 2012; McRae & Mauss, 2015).

Recent work in our lab has contrasted positive and neutralizing tactics in terms of their immediate and long-term effects on the informational content and emotional impact of negative autobiographical memories (Dore & Ochsner, under review). In this study we found that positive and neutralizing reappraisal evoke
long-term change in fundamentally different ways – positive reappraisal entails imbuing memories with a “silver lining” via the sustained addition of new positively valenced information whereas neutralizing reappraisal entails taking a more distant psychological perspective on the events of a memory in order to decouple one’s emotional response from the (comparatively) unchanged emotional memory content. This pattern of results suggests that these two strategies operate via distinct mechanisms and have distinct effects, raising the possibility that they may be more effectively leveraged for particular classes of evocative situations (e.g., those that contain some degree of positively valenced content or implication), a hypothesis that could be tested in future work.

Many theoretically meaningful strategy-related differences have received little empirical attention, including whether application of a strategy is intrinsically or extrinsically motivated, whether it is cued and implemented by the self or by another person (see Reeck, Ames, & Ochsner, 2015; Zaki & Williams, 2013), and whether it is motivated, cued, and/or implemented in a relatively explicit or implicit manner (see Mauss, Bunge, & Gross, 2007; Gyurak, Gross, & Etkin, 2011).

2. Translate lab findings into novel applications and modes of field experimentation. As the experimental study of emotion regulation becomes increasingly mature, we will be able to move toward careful translation of findings, ideas, and techniques into real-world contexts, including novel applications and novel modes of field research. In field studies of emotion regulation, we can apply observational methods to better characterize spontaneous regulatory tendencies,
and apply experimental manipulations in the field in order to identify capacities that are sustained over time and evoked in a natural context.

A recent project from Morris and Picard (2014) combined translation and field experimentation to develop and evaluate of a novel online intervention -- the Panoply application -- that administers emotion regulation training and social support by crowdsourcing reappraisals and empathic responses from other trained users of the application. Relative to a control platform that facilitated expressive writing, Panoply led to larger increases in reappraisal use for people who were higher in depression at baseline, indicating an interaction such that socially-oriented forms of emotion regulation training may be particularly beneficial for people with higher levels of depression (Morris, Schueller, & Picard, 2015).

3. Relate daily life processes to the operation of basic mechanisms.

Although most studies focus exclusively on either lab-based or daily life processes, empirical connections between naturalistic and lab instances of emotion regulation can be made in a single study, and even within the same subjects. The importance of this kind of work has been pointed out by other theorists (Aldao, Sheppes, Gross, 2014; Berkman & Falk, 2013), and empirical study has increasingly attended to testing lab-life associations. In principle, any study relating lab-based behavioral or brain results to retrospective questionnaires enhances our knowledge of such associations, but the combination of lab measures with EMA methods or other ambulatory assessments show particular promise in this regard. By collapsing across measurements collected for particular persons, EMA can be used to ask individual difference questions, adding to and validating the extant questionnaire-
based literature, and by considering each person’s deflection from baseline across different situations, these methods can also be used to ask situation-focused questions more directly than questionnaire or lab studies (see Bolger, Davis, & Rafaeli, 2003; Brans et al., 2013; Nezlek & Kuppens, 2008).

In a recent example from our lab, we used a Twitter dataset to identify patterns of emotional word use in response to a national tragedy (the Sandy Hook Elementary School shooting) over space and time. Although sadness words decreased with time and spatial distance, anxiety words showed the opposite pattern, associated with increases in words reflecting causal thinking. Moreover, increased feelings of anxiety were driven by perceptions that the causes of this event are unresolved (Doré, Ort, Braverman, & Ochsner, 2015). This pattern suggests that the modulation of emotion that occurs over time and space can be attributed in part to top-down cognitive processes (i.e. abstract causal thinking) that diminish sadness while simultaneously increasing other emotions, like anxiety.

**Methodological and Analytic Considerations**

A person-centered science of emotion regulation, even more so than the group-average centered approach dominant in the past, will benefit from the application of modern tools for data collection and analysis. Below, we highlight two important considerations: greater diversity in the kinds of data leveraged and a shift in statistical focus toward the estimation of effect sizes with uncertainty and variation.

**Expanding the psychology lab.** Practical considerations inherent in conducting a psychology study have changed dramatically in the past ten years, and
we expect that they will continue to do so (see Yarkoni, 2012). For example, the emergence of Internet-based sampling has facilitated efficient access to large and diverse samples of participants. Moreover, as people’s interactions with the world become increasingly intertwined with their use of the Internet, new opportunities will emerge for the collection of psychologically-relevant records of actual behavior across life contexts (Gosling & Mason, 2015).

**Embracing the “new statistics”: estimation with variation.** An interactive approach to person, situation and strategy sources of variability in emotion regulation aligns well with recent examinations of and recommendations for statistical practice in psychology (Gelman & Carlin, 2014; Simmons, Nelson, & Simonsohn, 2011; Cumming, 2013). In particular, we expect that the future of emotion regulation will move gradually away from statistical approaches that seek to categorically accept or reject hypotheses about the existence of a particular regulatory effect and towards approaches that seek to estimate the magnitude of theoretically motivated interactions.

Multilevel approaches to data analysis are particularly well suited to the estimation of context-varying effects, because they can incorporate random effect terms allowing effects of interest to vary from person to person (Bolger & Laurenceau, 2013; Gelman & Hill, 2008). With these models, we can ask which documented emotion regulation effects are true for nearly everyone and which are characterized by more variability, even before we have identified the factors that generate this variability. A recent investigation used a multilevel technique (latent class analysis) to characterize person-specific patterns of strategy use, finding that
elevated use of regulation strategies overall, and elevated use of avoidance and rumination strategies in particular, was associated with psychopathology symptoms (Dixon-Gordon, Aldao, & De Los Reyes, 2014).

Another strength of multilevel modeling is that it can reveal that relationships of interest are different at between- and within-person levels. In a recent example from our lab (Silvers, Wager, Weber, & Ochsner, 2015), we sought to examine the neural mechanisms that underlie spontaneous variation in negative affect felt in response to aversive images. In a between-person analysis, we found that people with lower average levels of negative affect more strongly recruited ventromedial prefrontal cortex (vmPFC), a region known to support contextual updating of affective value (Roy et al., 2012), including signalling a state of safety and extinguishing conditioned fear (Schiller & Delgado, 2010). In a within-person analysis, we found that lower levels of negative affect on a given trial were associated with lateral and medial prefrontal activity, whereas higher negative affect ratings were associated with amygdala activity. These within-person effects closely resemble the brain activity associated with instructed reappraisal – suggesting that phasic changes in these regions may reflect spontaneous engagement of resources for cognitive emotion regulation (Buhle et al., 2014). In this and other cases, parceling out within- and between-person sources of variability can lead to new scientific insights, avoid the erroneous assumption that variation from person to person follows the same rules as variation from situation to situation, and serve theoretical movement towards person-centered paradigms in the neuroscience and psychology of emotion regulation.
Conclusion

As emotion regulation research continues to mature, it is becoming clear that the utility of any given regulation strategy will depend on characteristics of the person leveraging it and the evocative situation it is being leveraged against. Here we provide a model of the person, situation, and strategy influences on discrete temporal stages of the emotion regulation process. We suggest that an overarching scientific framework in which these contextual dependencies are foregrounded can serve to integrate basic and translational approaches to studying emotion regulation. We hope that such a framework can usefully guide observational and experimental approaches to field and lab research, aid in the development of a comprehensive model of emotion regulation with transportable relevance, and eventually give rise to a nuanced understanding of how, when, and for whom different strategies for emotion regulation can be most effective.
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References


Doré, B.P. & Ochsner, K.N. (under review.) Reappraisal evokes lasting change in the content and emotional impact of negative autobiographical memories.


Table 1. A) Descriptions of person, situation, and strategy main effects and two-way interactions manifest within identification, selection, and implementation stages of emotion regulation. B) Recent findings (in black) and hypotheses for future work (in grey italics) that illustrate person by situation, person by strategy, and situation by strategy interactions in emotion regulation.

Table 2. Characteristic studies of emotion regulation that have applied one-way and two-way factorial designs.

Figure 1. Model of sources of variability in emotion regulation success, including main effects of person, situation, and strategy factors as well as their interactions (listed factors are meant to be illustrative rather than exhaustive). Whether a particular strategy (e.g., distraction, reappraisal, or expressive suppression) leads to successful regulation depends on characteristics of the person leveraging it and the situation it is leveraged against.

Figure 2. Model of the knowledge generation process in emotion regulation research. Scientists generate knowledge by enriching lab paradigms, translating lab findings, and relating daily life processes to underlying mechanisms.