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Proactive Versus Reactive Emotion Regulation: A Dual-Mechanisms Perspective

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Emotion regulation (ER) relies on cognitive processing, but the foundational control mechanisms involved remain unclear. The process model of ER posits that different strategies occur at different points in time, with antecedent strategies occurring relatively early and response-focused strategies later in the affective time course. In parallel with this model, the dual mechanisms of control (DMC) theoretical framework proposes that cognitive control operates via 2 temporally distinct modes: anticipatory preparation to exert control (proactive control) and momentary cognitive engagement as the need arises (reactive control). However, empirical investigations of the role of proactive and reactive control in ER have been limited. In this article, we examine how ER processes can be characterized within the DMC framework, integrating these 2 theoretical perspectives. We first posit that any ER strategy may take place either prior or subsequent to onset of an emotional stimulus, depending on whether it is proactively or reactively enacted. Then, using reappraisal as an example, we discuss ER strategy use via both control modes. We further assert that proactive ER can be implemented in a global- or stimulus-dependent fashion and discuss how this implementation may affect the time course and cognitive load of ER strategies. We conclude by discussing how controlling for timing in future research may clarify how populations with reduced cognitive control may demonstrate intact ER (i.e., through greater reliance on reactive and/or global strategies) and how incorporation of the DMC perspective may inform ER interventions for clinical populations.

Keywords: emotion regulation, cognitive control, temporal dynamics, dual mechanisms

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Emotional responses can be highly adaptive and crucial to survival, motivating both reward approach and threat avoidance (Panksepp, 2004). Mechanisms that facilitate adaptive control and minimize maladaptive control of emotions, or *emotion regulation* (ER), are important—emotion dysregulation is indicative of poor psychological outcomes, including depression, anxiety, and substance abuse (Aldao & Nolen-Hoeksema, 2012). Although the link between emotion regulation and fundamental cognitive control mechanisms is widely recognized, the specific control processes involved in ER remain undercharacterized.

Within the cognitive literature, the dual mechanisms of control (DMC) framework (Braver, 2012; Chiew & Braver, 2017) is an influential conceptualization of cognitive control as operating in two modes: one mode characterized by anticipatory preparation to use control (proactive) and the other characterized by in-the-moment, flexible control engagement as the need arises (reactive). For example, driving from one destination to another can be conceptualized as depending on relatively proactive or reactive control strategies and transitions between them: mapping out one's route ahead of time (proactive) versus generating an alternative route in response to an unexpected road closure (reactive).

The DMC framework has been used to characterize the cognitive processes, brain mechanisms, and physiological time courses by which cognitive control operates. However, potential distinctions between proactive and reactive ER have been underexplored to date. In the present article, we review the DMC framework as a theoretical model for understanding cognitive control processes and argue for the utility of explicitly characterizing ER processes in terms of this framework. We apply the DMC framework to ER by (a) reviewing the classic DMC model and proactive versus reactive modes of cognitive control; (b) discussing how proactive versus reactive ER may differ in temporal dynamics; (c) discussing how global versus stimulus-dependent regulatory targets may further impact cognitive processes in reappraisal; and (d) proposing a model of dual mechanisms of control in ER, conceptualizing cognitive control in terms of regulation onset timing and specificity (e.g., dependence on eliciting stimulus). Finally, we discuss the impact of this model on understanding ER in populations with cognitive control difficulties and overview future directions for research.

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The DMC Model and Cognitive Control Across Proactive and Reactive Modes

The DMC framework posits two separate, complementary methods for orchestrating cognitive control in support of adaptive goal-directed behavior. The first mode, *proactive control,* is characterized by sustained or preparatory goal maintenance, engaged prior to anticipated task demands. In contrast, *reactive control* may act as a "late correction" mechanism, solicited in response to transient environmental signals such as feedback or conflict. These modes are temporally distinct: Proactive control is posited to be relatively more sustained and/or emerging earlier, whereas reactive control is posited to be relatively transient and emerges later, in response to control demands as they arise. Further, proactive control has been linked specifically to active maintenance of information in working memory and sustained/anticipatory activity in dorsolateral prefrontal cortex (DLPFC; Braver, 2012). Many empirical studies supporting the distinction between proactive and reactive control have utilized the AX-continuous performance task (AX-CPT), where participants must actively maintain cue (context) information and respond to a cue−probe combination on each trial. Participants are instructed to execute a target response to a specific cue−probe combination (e.g., an A cue followed by an X probe) and execute an alternate response to any other cue−probe combination. In the classic AX-CPT, the majority of trials require a target response (70% AX trials), with low-frequency alternate trial conditions (10% each): target cue, followed by a nontarget probe (AY trials); nontarget cue, followed by a target probe (BX trials); and nontarget cue, followed by nontarget probe (BY trials). In this task, the majority of trial responses are predicted in advance by the cue; thus, performance generally benefits from advance preparation (i.e., proactive control). The exception is AY trials, where cue-related expectancy must be overcome to respond correctly and performance benefits most from reactive control instead. Functional magnetic resonance imaging (fMRI) studies that have linked AX-CPT performance to DLPFC activity (Braver, Cohen, & Barch, 2002; Braver, Paxton, Locke, & Barch, 2009); notably, within the same DLPFC region, proactive control has been associated with sustained, preparatory activity, whereas reactive control is associated with transient, probe-based activity.

Although the distinction between proactive and reactive control (and associated temporal differences in prefrontal activity) has been made in the classic cognitive literature, this distinction has yet to be fully explored in ER. We argue that task designs enabling characterization of proactive versus reactive control could be more fully extended to the ER domain. Some ER studies (e.g., Goldin, McRae, Ramel, & Gross, 2008) have used cue−probe designs with structural similarities to the AX-CPT, including anticipatory cues (instructing use of one regulation strategy vs. another) preceding emotional probes on each trial. However, most designs lack sufficient delays between cue and probe to model these periods separately (discussed in Kalisch, 2009). To illustrate this point, we evaluated studies included in a recent review of published reappraisal paradigms (Ochsner, Silvers, & Buhle, 2012; Table 1) and found that designs provide participants with either an *early* cue prior to emotional stimulus (43/57 studies) or a *late* reappraisal cue following an emotional stimulus (14/57 studies); therefore, there is a lack of both *early* and *late* cues within the same study. This makes it challenging to model potential differences in cue- and probe-related activity across proactive and reactive trials, despite the suggestion that ER preparation/maintenance and ER use are unique processes that both recruit prefrontal cortex (PFC) activity (Kalisch, 2009).

Emotion Regulation Has an Established Link With Cognitive Control Processes

ER strategies such as reappraisal (changing one's cognitive construal of the situation; i.e., seeing the "silver lining" in a

Table 1
Sample Paradigms With Brief Descriptions of Experimental Task, Emotion Time Course and Regulation, and Key Outcomes

Reactive, stimulus-dependent
Hajcak and Nieuwenhuis (2006)
• After viewing unpleasant images, participants either reinterpreted or simply attended to the image
• Greater reduction in LPP response versus baseline, during reappraisal versus passive viewing
Proactive, stimulus-dependent
Goldin, McRae, Ramel, and Gross (2008)
• Participants were trained on both reappraisal and suppression
• Cued to engage in one strategy or the other before viewing disgust-inducing videos in an fMRI scanner
• Both strategies decreased emotional experience and increased activity in cognitive control brain regions
• Only reappraisal trials showed a decrease in activity in emotion brain regions
Proactive, stimulus-independent (global)
Herwig et al. (2007)
• Participants trained on reality checking, a form of reappraisal; a control group received no training
• Compared neural responses when participants were cued versus uncued to the valence of the upcoming image
• Compared to the untrained group, trained participants showed greater reduction in activity in emotion regions and greater increase in activity for cognitive control regions during image viewing
• Greater increase in PFC activity during regulation in cued versus uncued trials
• Compared with untrained participants, trained participants showed greater decrease in emotional experience for both cued and uncued trials

Note. These categorizations are post hoc; new paradigms deliberately designed to characterize proactive or reactive emotion regulation processes are called for. LPP = late positive potential; fMRI = functional magnetic resonance imaging; PFC = prefrontal cortex.

negative situation, or focusing on positive overall outcomes) rely on many cognitive control processes, including keeping the initial interpretation of a situation in mind, generating alternate interpretations of that situation, and updating the meaning of the negative situation to the most helpful reappraisal (Ochsner et al., 2012). Reappraisal success has been linked to core cognitive processes including working memory capacity and set-shifting costs (McRae, Jacobs, Ray, John, & Gross, 2012) as well as fluid reasoning (Opitz, Lee, Gross, & Urry, 2014). Neuroimaging findings link reappraisal to activity in prefrontal and parietal cortex (Morawetz, Bode, Derntl, & Heekeren, 2017), including DLPFC regions active during proactive and reactive control. Additionally, functional connectivity between prefrontal regions and emotional salience−related regions, such as the amygdala, increases with ER success (Urry et al., 2006; Winecoff, LaBar, Madden, Cabeza, & Huettel, 2011). However, despite extensive literature suggesting that working memory and cognitive control are crucial to ER processing, implementation of proactive versus reactive control processes in ER has yet to be systematically disentangled.

Proactive and Reactive Emotion Regulation May Differ in Their Temporal Dynamics

Timing differences in affective processing have been explored across ER strategy classes of the *process model of emotion regulation* (Gross, 2014). This model outlines an iterative timeline of emotional generation and points for potential intervention that unfold in stages, starting with engagement in an emotion-evoking situation and culminating in outward emotional expression. The process model of ER temporally distinguishes between *antecedent strategies,* such as situation selection, attentional deployment, reappraisal, and distraction, which are generally conceptualized as occurring prior to emotional response, versus *response-focused* strategies, such as emotional suppression, which may occur later, after the emotion has been generated (Dan-Glauser & Gross, 2011). Whereas reappraisal is mostly associated with early, transient DLPFC activation (as demonstrated in both electroencephalograph [EEG] and fMRI activity; Moser, Krompinger, Dietz, & Simons, 2009; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011), other reports have demonstrated increased DLPFC activation over the reappraisal time course (e.g., Kalisch, 2009). This distinction between antecedent- and response-focused strategies is important, but temporal dynamics may vary even within one antecedent strategy. Given that ER is an iterative process of evaluating expectations, emotional outcomes, and deciding whether to intervene (Gross, 2015), it follows that the same ER strategy may lead to either early or late DLPFC involvement, depending on strategy implementation. This may help explain discrepancies in PFC activity time courses across previous reappraisal studies. To our knowledge, no systematic comparison of proactive versus reactive implementation of a single ER strategy exists, although a few investigations of ER have begun to characterize ER anticipation and preparation separately from use (please refer to suggested additional readings in the online supplemental materials). For example, Denny and colleagues observed that anticipatory insula activity was negatively associated with later amygdala activity and efficacy during reappraisal use (Denny, Ochsner, Weber, & Wager, 2014). Furthermore, Vanderhasselt and colleagues characterized anticipatory activity in prefrontal regions as predictive of successful use of a suppression-based ER strategy (Vanderhasselt, Kühn, & De Raedt, 2013).

Proactive and Reactive Emotion Regulation Vary by Regulation Onset and Stimulus Specificity

Strategy timing has been identified as a potential contributor to ER success (Sheppes & Gross, 2011), but most designs do not manipulate strategy onset systematically (as reviewed in Kalisch, 2009). Although reappraisal is often cued in advance, insufficient delay periods between cue and strategy use in most designs (see Kalisch, 2009) may not enable characterization of proactive ER processing. In addition to considering differing time courses across ER strategy classes, we argue that each specific ER strategy may be implemented in either a proactive or a reactive manner, depending on the timing of strategy preparation and use. In reactive ER, strategy preparation and use may occur simultaneously, whereas in proactive ER, preparation may occur prior to strategy use.

Within this conceptualization, any given strategy may potentially be used at a relatively early or late phase within the time course, depending on preparation and use of that strategy. For instance, consider a patient awaiting a result from a recent biopsy. In the case of reappraisal, *prior* to receiving the biopsy result, the patient could proactively prepare to focus on the positive aspects of the result no matter what the result is (e.g., "When I find out my result, I will focus on what I will learn from the experience"). Alternatively, one could implement a reactive ER strategy *after* receiving the result and focus on how the prognosis is better than it may have seemed immediately after receipt.

In addition to regulation onset, we also argue that ER strategies may demonstrate different cognitive time courses as a function of how dependent a reappraisal is on the emotional stimulus encountered (global vs. stimulus-dependent reappraisals). Considering the example just described, both the proactive and reactive strategies refer to the specific eliciting stimulus (biopsy result), but the patient could also utilize a global, one-size-fits-all reappraisal that is both proactive and independent of the biopsy outcome (e.g., "Everything will be okay no matter what the result").

This conceptualization suggests that ER strategies are utilized either proactively or reactively, as well as in either a global or stimulus-dependent manner. This represents an expansion of the process model, because each ER strategy may be flexibly implemented proactively or reactively, at different phases of the process model's iterative time course, rather than being associated with a specific time point. We visualize these potential regulation dynamics in Figure 1.

Note that in this article, we have focused on reappraisal and its implementation via proactive and reactive modes, but other ER strategies (including, for example, attentional deployment and suppression; Gross, 2014) may also be conceptualized within the DMC framework. In Figure 1, we provide theoretical time courses for proactive and reactive ER. It is important to note that these apply to reappraisal but also across strategy classes of the ER process model. For instance, late onset cognitive activity during emotion suppression has been associated with reactive, stimulus-

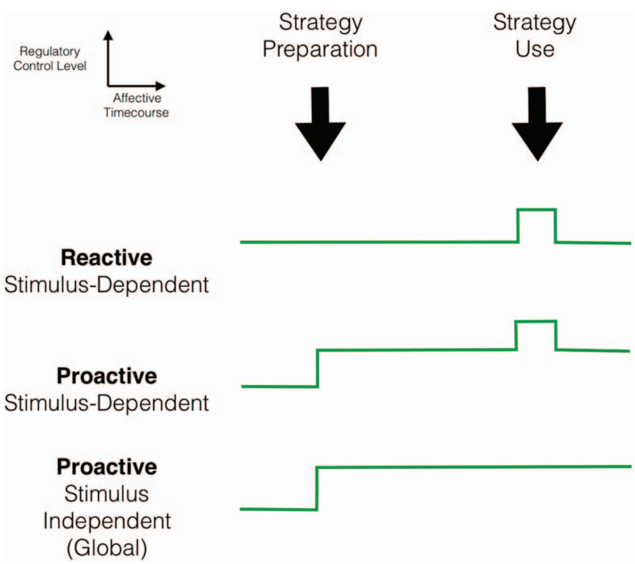

Figure 1. Proposed time courses of emotion regulation strategies as potentially reactive and stimulus-dependent, proactive and stimulus-dependent, or proactive and stimulus-independent (global). As indicated in the different profiles of the time courses, regulatory control processes can be implemented in a more phasic, event-locked fashion; a more global, sustained fashion; or a combination of the two. Further, control can be implemented at different stages in the affective process. See the online article for the color version of this figure.

dependent transient activity peaking after the emotional response was under way (Dan-Glauser & Gross, 2011). Our proposal extends previous findings, highlighting how proactive strategies may engage sustained or preparatory cognitive control, versus transient reactive strategies, and additionally how global strategies may lead to earlier, sustained cognitive control versus stimulus- or response-specific ER tactics.

Table 1 highlights specific experimental paradigms that can be understood as consistent with these categorizations. It is important to note that these categorizations are presently post hoc; ER strategies and their neural substrates will need to be investigated using paradigms deliberately designed to engage proactive versus reactive control mechanisms to confirm the utility and validity of these distinctions.

Utility and Applications of a DMC Framework for Advancing Understanding of Emotion Regulation

As discussed earlier, ER strategies can be understood as operating in either a proactive or reactive fashion, but most ER investigations have not been designed to separate these control modes. We suggest that characterizing ER in terms of this theoretical framework will help account for performance variability by advancing understanding of the control mechanisms involved, their neural substrates, and the timing by which they are engaged. This parallels the DMC framework's utility in the study of classic cognitive control, where it has been used to account for variability in and formulate predictions regarding cognitive performance across situational contexts, individuals, and population groups (Braver, 2012). Multiple factors can contribute to ER success; although it is clear that cognitive control is involved in ER, the DMC framework sets up formal predictions for the contributions of different control modes in a mechanistically explicit way.

Specifically, the DMC approach may help elucidate longstanding questions regarding variability in ER performance across populations. For example, a "paradox of aging" has been suggested: Cognitive control decline in older adults (OAs) is well documented, yet superior ER and well-being has been characterized in this age group relative to younger adults (Mather, 2012). Given the importance of cognitive control processes to ER, this paradox has posed a riddle to researchers. Studies investigating basic cognitive control in OAs using a dual-mechanisms perspective have suggested that older adults have a specific deficit in proactive control, whereas reactive control remains relatively preserved (Paxton, Barch, Racine, & Braver, 2008; Paxton, Barch, Storandt, & Braver, 2006). Given intact reactive control in this population, the superior ER abilities observed in OAs may be linked to two potential differences relative to young adults: (a) preferential use of strategies relying on reactive versus proactive control and (b) greater use of strategies depending on less cognitive control more generally. More cognitively demanding strategies, such as reappraisal, are more effortful than is simple distraction for OAs (Martins, Florjanczyk, Jackson, Gatz, & Mather, 2018), but the contributions of proactive versus reactive control mechanisms in ER across different age groups has yet to be clarified. Whereas the cognitive literature often depicts reactive control as associated with poorer task performance (Edwards, Barch, & Braver, 2010; Paxton et al., 2008), the potential adaptive value of reactive ER strategies remains unknown.

Clarifying the effort involved in proactive and reactive control, and how it impacts the utility of ER strategy use, is also crucial to advancing therapeutic interventions. Further, clarifying differences in the efficacy of stimulus-dependent versus global strategies will be helpful in tailoring interventions to specific groups. For instance, OAs with late-life mood disorders may demonstrate different costs and benefits of proactive preparation to regulate (e.g., engaging in daily morning mindfulness) versus reactive regulation (engaging in a grounding strategy following a distressing situation). Other populations with ER and cognitive control difficulties, such as children with conduct problems and patients with schizophrenia, may also benefit from this future research. Proactive control training has been shown to improve cognitive performance in schizophrenia patients (Edwards et al., 2010); it is unclear whether proactive ER training may similarly benefit downstream emotional outcomes. If proactive control of emotion leads to greater emotional benefits, cognitive training (perhaps implemented via mobile technologies) could help boost use of anticipatory strategies in populations that struggle to engage these strategies independently.

Conclusion

The DMC framework has important utility in clarifying the control mechanisms underlying ER and variability in its performance at multiple levels of analysis. As reviewed, most experimental paradigms investigating ER do not explicitly characterize contributions of these two control modes, nor do they differentiate stimulus-dependent strategies from those that are more global. Whereas we have focused on reappraisal strategies here, one can consider proactive versus reactive approaches, as well as stimulus-dependent considerations, across other ER strategies, including detached reappraisal, response suppression, and attentional deployment (Todd, Cunningham, Anderson, & Thompson, 2012). Additionally, whereas we have focused on strategies within the ER process model, the DMC framework may be applied to other theoretical perspectives of ER as well, including interpersonal ER and other developmental accounts (Eisenberg, Spinrad, & Eggum, 2010). We suggest that an important direction for future ER research will be to utilize experimental designs that deliberately engage regulation processes in a proactive versus reactive fashion and enable characterization of the temporal dynamics of these processes as they unfold.

Considering the DMC perspective will enable further application of theoretically motivated predictions from the classic cognitive control literature, strengthening existing models of ER. This integrative approach may help clarify some of the longstanding puzzles regarding the mechanisms of successful emotion regulation and their variability across populations.

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