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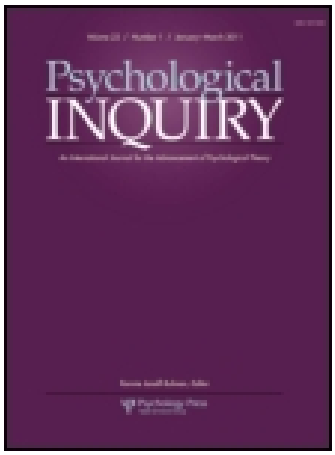

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Looking at Emotion Regulation Through the Window of Emotion Dynamics

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Looking at Emotion Regulation Through the Window of Emotion Dynamics

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In his target article, James Gross presents an extended version of his process model of emotion regulation that has deeply shaped the field of emotion regulation research. The extended process model of emotion regulation does not simply reflect a recapitulation of previous formulations of the original model, but constitutes a significant step forward. On a theoretical level, the extended model clearly identifies the generic process mechanisms behind emotion generation and regulation (both originating from hierarchically layered valuation or appraisal systems). As such, it proposes an answer to the long-standing debate whether and how emotion generation and regulation are different or the same (e.g., Gross & Barrett, 2011; Kappas, 2011). On an empirical level, it formulates clear predictions on how the different strategies put forward in the original process model originate from these underlying mechanisms and gives clues to where different forms of individual differences and emotion dysregulation find their origins.

One of the most striking features of the extended process model is that the dimension of time takes a central role. The activation of a goal to influence the emotion trajectory over time is presented as the defining feature of emotion regulation (Gross, this issue, p. 8), with emotion regulation being a temporal process in itself. Any theory of emotion regulation is therefore a theory about what people do to change the course of emotions across time.

This proposition has two important consequences. First, the explanatory power of the extended process model of emotion regulation can be evaluated by examining to what extent the theory contains the necessary ingredients to account for variability in the central dynamical features of emotion trajectories. Second, temporal patterns of emotional responding provide a window onto emotion regulatory processes that are at work even when no direct information on emotion regulation is available.

The aim of this commentary is to approach the extended process model from the perspective of research on emotion dynamics by examining the relationship between central dynamic features of the emotional response and elements of the extended process model of emotion regulation. This will allow to bridge research on emotion regulation and on emotion dynamics and will allow an evaluation of the extended processes model in terms of how it is capable to explain central dynamical features of emotions.

Emotion Dynamics: Charting the Course of Emotion (Components) Across Time

The fact that our emotions change across time lies at the very heart of why we have emotions in the first place, namely, to alert us to important changes and events and to motivate us to deal with these changes (Frijda, 2007; Larsen, 2000; Scherer, 2009). The field of emotion dynamics is concerned with the study of such changes, more precisely with the trajectories, patterns, and regularities with which emotions, or one or more of their subcomponents (such as experiential, physiological, or behavioral components), fluctuate across time, their underlying processes, and downstream consequences (Kuppens, Stouten, & Mesquita, 2009).

Emotion trajectories can be obtained from studying reported or recorded components of emotions in lab settings or in daily life across time, such as self-reported emotional experience, recorded physiological indicators, or coded behavioral expression of emotions. Figure 1 shows a hypothetical example of such trajectories of two emotions, sadness and happiness. The emotion trajectories reflect the continuous, ongoing levels of these emotions. Even in the absence of clear emotion-eliciting events, people display or report fluctuations in emotions and affective experiences (due to a host of factors at various levels such as focus of attention, biological changes and rhythms, substance intake, etc.). The occurrence of an emotional event, however, may lead to a sharp and sudden change in the emotional trajectory, giving rise to the occurrence of an emotional episode, ending when the emotional trajectory returns more or less to its baseline level.

When studying emotion dynamics, one can either look for patterns and regularities in the continuous flow of emotional experience or zoom in on the dynamics that occur during a single emotional episode. Metaphorically, studying global emotional trajectories is like viewing a river from above and describing its overall flow, whereas studying

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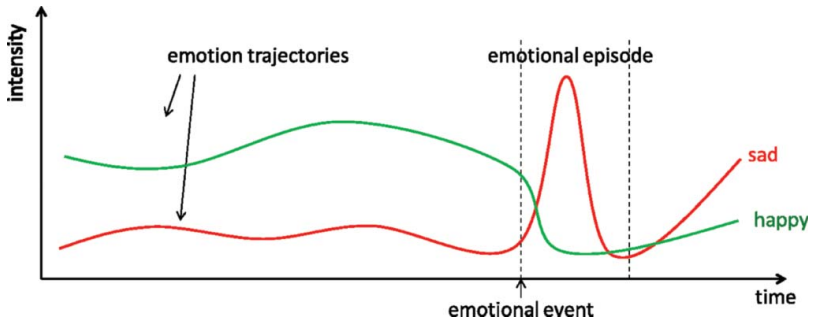

Figure 1. Two hypothetical emotion trajectories across time reflecting changes and fluctuations in sadness and happiness.

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emotional episodes is looking at what happens when a stone is thrown into the river (Koval, 2014). In what follows, we first focus on features of the overall emotional trajectories as they continuously unfold across time. Next, we hone in on the dynamics of a single emotional episode. For each, we discuss how they may originate from elements in the extended process model and explore how impairments or disruptions in these processes may give rise to emotion dysfunction.

Emotion Regulation in Features of Dynamical Trajectories of Emotions

Several elementary features of dynamical emotion trajectories can be discerned, each revealing distinct information about possible emotion regulatory processes at play. We introduce a taxonomy of emotion dynamical features that proposes a framework to capture the central features of how emotional trajectories evolve across time in people's lives. First, a crucial distinction has been proposed between two separate facets of emotional change: degree of variability (how much do experiences of emotions deviate from their mean across time) and time-dependency (how much does an emotion carry over from one moment to the next; e.g., Ebner-Priemer, Eid, Kleindienst, Stabenow, & Trull, 2009; Jahng, Wood, & Trull, 2008; Ram & Gerstorf, 2009). Second, we propose that these two facets can be considered for both single and multiple emotions. Combined, this gives rise to four distinct characteristics that together provide a picture of the dynamics of people's emotional lives: (a) emotional variability represents the range of fluctuations of single emotions (e.g., "I've seen high and low"), (b) emotional covariation represents how multiple emotions co-occur across time (e.g., "I feel sad and angry at the same time"), (c) emotional inertia represents how individual emotions carry over from one moment to the next (e.g., "I feel the same as before"), and (d) emotional cross-lags represent how the experience of one emotion feeds into the experience of another emotion from one moment to the next (e.g., "Feeling down makes me irritable"; see Figure 2 for a graphical depiction).

Each of these characteristics captures unique information about the dynamical unfolding of emotions across time. As emotion regulation is aimed at changing the temporal unfolding of an emotional response, one can assume that (variability in) the proposed dynamic features should at least partially be explained by elements of the extended process model of emotion regulation.

Emotional Variability

Emotional variability reflects the range with which emotions fluctuate across time (often captured by the standard deviation of emotion scores across time). Individuals are thought to differ reliably in their levels of emotional variability, to the extent that it is considered a traitlike feature (Eid & Diener, 1999). Essentially, this variability of fluctuations can be considered a direct consequence of the sensitivity of the valuation system that is generating the emotional response and the regulatory valuation system acting upon it. In that sense, the level of emotional variability an individual displays is an indirect gauge to the sensitivity of the valuation systems considered responsible for emotion generation and regulation in the extended process model. Higher levels of variability reflect highly sensitive valuation cycles that respond with great intensity to desirable or undesirable events (first-level valuation system) or to desirable or undesirable emotional states (second-level valuation system), whereas lower levels of variability reflect valuation systems that are less sensitive to changes picked up by either.[1]

[1]One could argue that high sensitivity could also give rise to continuous high levels of a particular emotion, resulting in low emotional variability. Although this may the case theoretically, empirically the mean and variability of emotion ratings across time are either not or positively correlated, implying that the occurrence of constant high levels of emotions is rather rare.

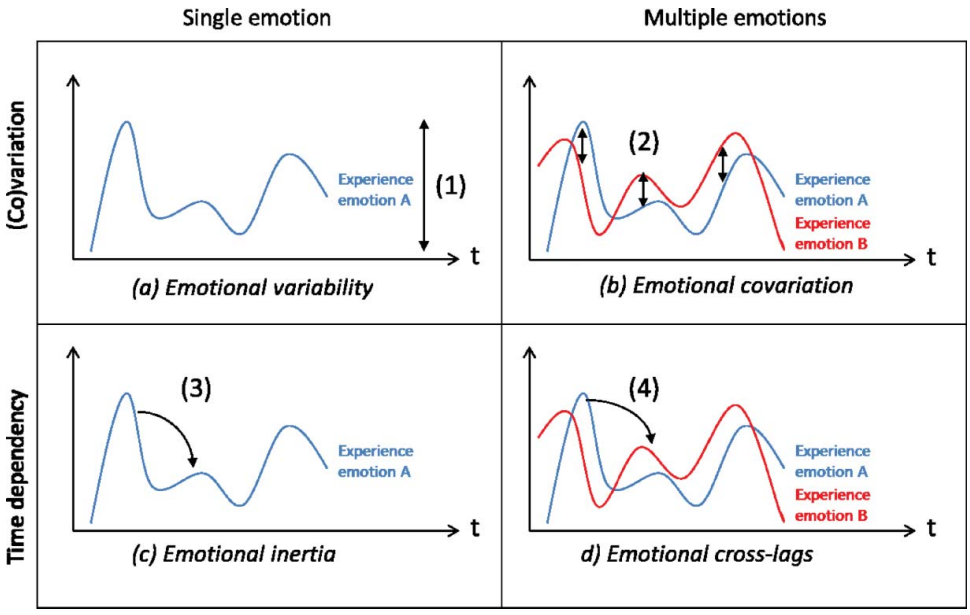

Figure 2. Taxonomy and graphical representation of four fundamental dynamical characteristics of emotional trajectories.

Both too high and too low levels of such sensitivity can be expected to be disruptive. This is reflected in findings from clinical emotion dynamics research showing that lack of variability (resulting from for instance emotion context insensitivity; Rottenberg, 2005) and too large levels of emotional variability (e.g., Peeters, Berkhof, Delespaul, Rottenberg, & Nicholson, 2006; Thompson et al., 2012) are associated with the presence and symptom severity of mood disorder.

Emotional Covariation

Zooming more into the extended process model, the identification stage of emotion regulation concerns identifying the need for emotion regulatory action (Gross, this issue). A first prerequisite for such identification is that people are aware of their emotions. Emotional awareness implies that people can identify the distinct emotional states they are experiencing and their proper causes and consequences so as to be better equipped with knowledge and ammunition to regulate them. Deficiencies in emotional awareness inevitably form the basis for problems in regulating one's emotions (in terms of its frequency, self-efficacy, and ability).

One specific type of difficulty in emotional awareness is that people are less capable of differentiating between different emotional states. The level at which people are able to differentiate between different emotional states has been labeled emotion differentiation or emotional granularity (Barrett, Gross, Christensen, & Benvenuto, 2001) and can be directly inferred from observing the level of covariation between the fluctuations of different emotional states across time (e.g., Barrett et al., 2001; Erbaş, Ceulemans, Pe, Koval, & Kuppens, 2014). The underlying idea is that people who differentiate strongly between different states will show relatively low levels of covariation between different emotions across time (or contexts), whereas people who don't differentiate strongly show higher levels of covariation (Barrett et al., 2001). Thus, in a nutshell, the level of emotion differentiation provides an indirect indicator of the emotional awareness that provides the impetus for undertaking emotion regulatory action in the identification substage of the extended process model.

Consistent with the predictions from the extended process model, low levels of emotion differentiation (indicating low emotional awareness) are related to less deployment of emotion regulatory actions (Barrett et al., 2001) and lower ability to regulate emotions as evidenced by a recent surge of studies illustrating how emotion differentiation can be seen as a hallmark of adaptive emotional functioning and regulation (Erbaş et al., 2014; Kashdan, Ferssizidis, Collins, & Muraven, 2010; Tugade, Frederickson, & Barrett, 2004).

Emotional Inertia

Emotional inertia reflects the tendency for emotions to carry over from one moment to the next, reflecting a resistance to change (Kuppens, Allen, & Sheeber, 2010; Suls, Green, & Hillis, 1998). It is usually captured by examining the autocorrelation of emotion scores across time. A higher autocorrelation reflects an emotion that is more self-predictive over time, with the previous state being highly influential

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for predicting the current state. Theoretically, emotional inertia was conceived to reflect both decreased emotional reactivity and impaired emotion regulation skills (Kuppens et al., 2010), but empirically, inertia seems to mainly and most consistently stem from difficulties regulating one's emotions (Koval et al., 2014; Suls et al., 1998).

The dynamic feature of emotional inertia may arise from two locations in the extended process model put forth by Gross (this issue). First, emotional inertia may result from the psychological inertia that Gross identified as impairing the action substep in the identification stage of emotion regulation, reflecting the fact that people may (to a varying extent) tend to continue a current course of action, thinking, or emotion, instead of changing it. Such a perseverative tendency may result from a variety of sources, such as the inability to flexibly adapt to changing circumstances (see Kashdan & Rottenberg, 2010, for a review) or the fact that an emotion regulatory goal is less salient or pressing. Second, emotional inertia may not necessarily result from the lack of an emotion regulatory goal, but may result from an inability to effectively regulate the emotion despite the motivation to do so. As such, emotional inertia can be considered the emotional dynamical indication that the emotion regulation apparatus has grinded to a halt, not changing or imposing on the trajectory of an emotion any longer, but instead letting it run its course.

Research from emotion dynamics is consistent with these notions. Emotional inertia is related to cognitive perseverative tendencies such as rumination (Koval, Kuppens, Allen, & Sheeber, 2012). Emotional inertia is also linked to inefficient (at least in the sense of having impact on emotional experience) regulatory strategies such as suppression (Koval, Butler, Hollenstein, Lanteigne, & Kuppens, in press). Moreover, it is not surprising that as emotional inertia reflects emotional resistance to change and thus the general failing of emotion regulation goals and efforts, it is associated with poor psychological adjustment. Indeed, research has shown that emotional inertia is related to higher levels of neuroticism (Kuppens et al., 2010; Suls et al., 1998), depression symptoms and diagnosis (Koval et al., 2014; Koval et al., 2012; Koval, Pe, Meers, & Kuppens, 2013; Kuppens et al., 2010), and even prospectively predicts the onset of depression across longer periods of time (Kuppens et al., 2012; van de Leemput et al., 2014).

Emotional Cross-Lags

At the core of Gross's extended model of emotion regulation lies a hierarchy of valuation systems that perceive and evaluate the changes in the world or one's state and that generate the motivation to act upon them. The dynamical interplay between subsequent cycles of one valuation system or between how one valuation system provides the input for another valuation system gives rise to a continuity in people's emotional lives across time. This continuity implies that emotional states provide input for subsequent emotional states over time (Gross, this issue, p. 19), which is reflected in the phenomena of emotional augmentation and blunting across time (Pe & Kuppens, 2012). Both are forms of so-called emotional cross-lags in which the experience of a certain emotion increases (augmentation) or decreases (blunting) the experience of another emotion at a next moment in time. For instance, feelings of sadness may infuse subsequent feelings of anger (augmentation), or anxiety may hinder the possibility of relaxation (blunting). Emotion augmentation and blunting can be studied by examining time-lagged cross-correlations between different emotions across time (where one emotion is predicted by itself and another emotion at a previous moment in time).

Applied to the extended process model, emotion augmentation or blunting can arise from the first-level (emotion generating) valuation system due to appraisal (valuation) tendencies that accompany an emotional experience and that influence the appraisal (valuation) of future events. The appraisal tendency framework (Lerner & Keltner, 2000) stipulates that the experience of particular emotions is accompanied by the tendency to appraise future events in emotion congruent ways. Building on this framework, emotion dynamics research has shown that emotion augmentation and blunting are a function of (individual differences in) the amount of overlap between the appraisal profiles underlying subsequent emotions: When two subsequent emotions show considerable appraisal overlap, the experience of the first will augment the experience of the next. Alternatively, when their underlying appraisal profiles diverge, the first will blunt the experience of the next (Pe & Kuppens, 2012; Winterich, Han, & Lerner, 2010).

Emotion augmentation and blunting can also arise from the second-level valuation system generating an emotion following the valuing an emotional state that is generated by the first-level valuation system. For instance, experiencing shame due to an event (first-level valuation) may give rise to the experience of anger about the experience of shame (second-level valuation), effectively leading to the observation of emotion augmentation between shame and anger in emotion dynamical patterns (e.g., Tangney, Wagner, Fletcher, & Gramzow, 1992). Alternatively, the experience of negative emotions will more likely than not be negatively valuated, leading to the buffering of experiencing positive emotions at a subsequent point in time (though instances of nonhedonic, instrumental emotion regulation provide a counterexample to this; Tamir, 2009).

Also in this context research from emotion dynamics has made clear that inflexibility in the dynamic

interplay between emotions may lie at the base of emotional maladjustment. For instance, high levels of emotional augmentation and blunting reflect an emotion system that is highly self-contained and self-predictive and less open to outside influences, resulting in a very dense emotion network that is characteristic of the emotion dynamics in mood disorder (Pe et al., in press).

Emotion Regulation in Dynamical Profiles of Emotional Episodes

In addition to continuous emotion trajectories, emotion dynamics researchers have also focused on dynamic properties of the emotional episodes that are interspersed in the continuous flow of emotional change. Research on emotion intensity profiles (i.e., temporal changes in the intensity or degree of activation of an emotional response (component) during an emotional episode over time (Verduyn, Van Mechelen, & Frederix, 2012) has revealed that these profiles are highly variable (Frijda, Mesquita, Sonnemans, & Van Goozen, 1991) differing both in *duration* (Verduyn, Delvaux, Van Coillie, Tuerlinckx & Van Mechelen, 2009) and *shape* (Verduyn, Van Mechelen, Tuerlinckx, Meers, & Van Coillie, 2009).

Duration

Contrary to traditional beliefs the duration of emotional episodes is not restricted to seconds or (a few) minutes at most (Frijda et al., 1991). The belief that emotions are short in duration is partially due to animal models that inspired emotion research (e.g., Darwin, 1872/1965), but in contrast to animals, human emotions do not always or even typically end when emotional circumstances vanish. Instead, human emotions often endure for a long time.

Rimé (2009) provided a compelling example illustrating this: Once a cheetah has caught an antelope and carries it away, the surviving antelopes do not show sustained fear but return to eating grass instead. Compare this example with the scenario of a shooter killing several people: The survivors of the attack will likely not return to business as usual within minutes. Recent empirical evidence confirms that an emotional episode may last for seconds, minutes, hours, or even longer in humans (for a recent review of the emotion duration literature, see Verduyn, Delaveau, Rotgé, Fossati, & Van Mechelen, in press).[2] This remarkable range in duration has a crucial implication for any theory of emotion regulation, namely, that regulation is a process that often unfolds over a long period. The time dimension is omnipresent in the extended process model of emotion regulation, but in many sections and associated illustrations no measurement unit or range for the time dimension is specified. Research on emotion duration indicates that this time dimension may vary considerably across episodes.

The extended process model of emotion regulation contains several elements that account for variability in the duration of an emotional response. First, according to this model the regulation process typically continues until the discrepancy situated at the first-level valuation cycle has been resolved. Regulating a high degree of discrepancy likely requires more time, which is consistent with evidence showing that long-lasting negative emotions tend to have multiple mismatches at their origin (i.e., the longest emotions were those that were caused by events that were perceived as inconsistent with one's goals, values, *and* self-ideal; Verduyn, Van Mechelen, Tuerlinckx, & Scherer, 2013). Second, according to the extended process model of emotion regulation strategies and tactics that are aimed at dissolving the first-level mismatch fasten emotional recovery. In contrast, strategies that do not interrupt the first-level valuation cycle do not speed up the recovery process. Consistent with these assumptions, long-lasting negative emotions were found to be characterized by rumination, whereas the presence of reappraisal and distraction was typical for short emotions (Brans & Verduyn, 2014; Verduyn, Van Mechelen, & Tuerlinckx, 2011).

Shape

Similar to duration, the shape of emotion intensity profiles is highly variable (Frijda et al., 1991). Verduyn and colleagues (Verduyn et al., 2009; Verduyn et al., 2012) inferred that these profiles mainly differ in degree of explosiveness, skewness, and number of peaks. Focusing on the emotion of anger, Heylen and colleagues further identified two frequently occurring intensity profiles: early- and late-blooming profiles (Heylen, Verduyn, Van Mechelen, & Ceulemans, 2014). Early-blooming profiles reflect anger episodes that peak at the start as a result of which recovery sets in rather fast. In contrast, late-blooming anger episodes reach their peak following a period of intensity accumulation only due to which recovery is delayed and the emotion prolonged.

According to the extended process model of emotion regulation, certain regulation strategies tend to down-regulate the emotional response, whereas other may cause emotion intensification. As such, strategies

[2]Moods are often differentiated from emotions based on a duration criterion with emotions being considered as shorter than moods (Beedie, Terry, & Lane, 2005). This relative order, however, does not imply that emotions are in absolute terms always or even typically short (Frijda et al., 1991).

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that down-regulate (up-regulate) the emotional response can be expected to occur relatively often during early-blooming (late-blooming) profiles. Empirical evidence is consistent with this claim. Heylen and colleagues (Heylen et al., 2014) found that reappraisal typically occurs during early-blooming anger profiles, which is consistent with the notion that reappraisal softens the discrepancy between the desired and actual state of the world by weakening the mismatch at the first-level valuation stage. In contrast, rumination was found to be characteristic of late-blooming profiles, which is consistent with rumination involving a persistent focus on the mismatch situated at the first-level valuation system combined with a lack of change in the valuation step. In short, specific regulation strategies described in the extended process model of emotion regulation account for variability in profile shape.

Research on the shape of intensity profiles is still in its infancy, but it may offer a unique insight in the occurrence of the emotion regulation process dynamics described by Gross: maintaining, switching, and stopping. Emotion maintenance can be expected during parts of the intensity profiles reflecting successful emotion regulation (e.g., a decrease in emotion intensity when aiming for emotion down-regulation). Emotion regulation switching can be expected when an intensity plateau is followed by a change in intensity level. Emotion regulation stopping is reflected by a return to baseline.

Conclusions and Future Directions

In our commentary we have tried to elucidate how observed patterns of emotion dynamics can be tied to the extended process model of emotion regulation. As a summary, Table 1 presents a schematic overview of different central emotion dynamical features, their measurement, and the aspects of the extended model of emotion regulation they are possibly associated with. As such, we aim to build a bridge between research on emotion regulation and emotion dynamics, elucidate how the two can inform each other and how combining the two can yield novel insights into the nature of emotion, emotion regulation, and emotion dysregulation.

The intrinsic relation between emotion regulation and emotion dynamics also implies that the study of emotion dynamics can reveal insights about the functioning of the emotion regulation process, even when no direct information on emotion regulation is available. In other words, the study of emotion dynamics allows researchers to make inferences about features of the emotion regulatory system without having to assess or manipulate emotion regulatory efforts or actions, which we believe presents interesting and promising opportunities for researchers interested in emotion and emotion regulation.

However, a note of caution is required at this point. Whereas emotion dynamical patterns can reveal information about emotion regulatory processes, it is certainly not the case that they result from

Table 1. *Overview of Emotion Dynamical Features and Their Relation to Emotion Regulation.*

Emotion Dynamic Feature	Calculation	Corresponding Emotion Regulation Aspects
Feature of emotional trajectory		
Emotional variability	Standard deviation of emotion (component) across time	Sensitivity of valuation systems involved in emotion generation and regulation
Emotion differentiation/ granularity	Covariation of emotions across time	Emotional awareness
Emotional inertia	Autocorrelation of emotion (component) across time	Psychological inertia and regulation failure
Emotion augmentation and blunting	Cross-lag correlation between emotions across time	Dynamical interplay between (cycles of) valuation systems
Feature of emotional episode		
Duration	Time difference between start and end of emotional episode	Duration of regulation process, discrepancy at first level valuation, regulation failure, regulation strategy
Intensity profile shape	fPCA component scores, K-SC cluster membership.	Regulation failure, regulation strategy, regulation process dynamics

fPCA = functional Principle Component Analysis; K-SC = K-spectral centroid

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emotion regulation only. Emotion dynamical patterns are the complex results of a number of factors, including but not limited to the frequency and intensity of events encountered in daily life, ongoing appraisal processes monitoring the relation between one's concerns and one's circumstances, biological diurnal patterns of emotion fluctuation and other hormonal factors, previous experience, and so on. Although emotion regulation may be involved in some or even many of these, it is important to point out that emotion dynamical patterns are the result not only of activated goals to influence the emotion trajectory (see the definition of emotion regulation; Gross, this issue) but also of how we appraise the world, what we eat and drink, our sleep, the weather, music, and someone smiling at you at the counter.

Finally, we end with formulating two directions for future research we think would bring forth the most promising offspring of the marriage between emotion dynamics and emotion regulation research. First, on a theoretical level, infusing the extended process model of emotion regulation with knowledge from appraisal theories would even more allow to pinpoint the processes at play behind the dynamics of emotional responding. As appraisal theories of emotions are quite explicit about which types of appraisals (or valuations) give rise to or are associated with specific types of emotions, this would allow the extended process model to make even more concrete predictions about emotion regulation and emotion dynamical implications for particular emotions. For instance, focusing one's attention on the aspect of blame in a given situation should have consequences for feelings of shame, anger, or guilt (but not necessarily surprise), or reappraising the power one has over a situation may affect feelings like anger and pride (but not necessarily guilt). In addition, a focus on appraisal would also entail a more explicit consideration of the context in which emotion regulation takes place, leading to predictions about in what types of contexts certain emotion regulatory efforts may be more or less effective, and how people go about flexibly changing emotion regulation efforts across contexts (see Aldao, 2013). Second, on an empirical level, emotion regulation has been primarily studied in the lab across short timescales (for a recent exception, however, see, e.g., Brans, Koval, Verduyn, Lim, & Kuppens, 2013). Research on emotion regulation in daily life across larger timescales is needed to get a better understanding of the role of emotion regulation on the temporal unfolding of an emotional response, and this in ecological circumstances. Clearly, stepping outside of the lab comes with the price of losing tight control on third factors, but it does give a rich insight into the diversity and complexity of real life.

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Note

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