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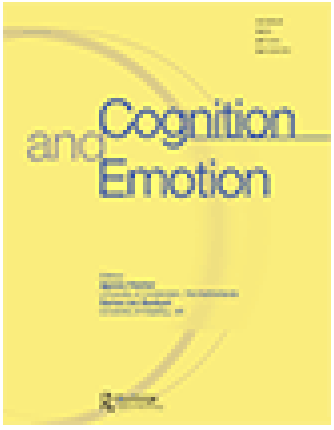

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Variability in anger intensity profiles: Structure and predictive basis

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BRIEF REPORT

Variability in anger intensity profiles: Structure and predictive basis

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The aim of this study is to describe variability in the shape and amplitude of intensity profiles of anger episodes and how it relates to duration, and to investigate whether this variability can be predicted on the basis of appraisals and emotion regulation strategies used. Participants were asked to report on a wide range of recollected anger episodes. By means of K-spectral centroid clustering, two prototypical shapes of anger intensity profiles were identified: early- and late-blooming episodes. Early-blooming episodes are relatively short and reach their peak immediately. These profiles are associated with low-importance events and adaptive regulation. Late-blooming episodes last longer and reach their peak (relatively) late in the episode. These profiles are related to high-importance events and maladaptive regulation. For both early- and late-blooming profiles, overall amplitude is positively associated with event importance and the use of maladaptive regulation strategies and negatively with the use of adaptive ones.

Keywords: Intensity profiles; Emotional experience; Time dynamics; Emotion regulation; Functional data analysis.

As emotions are processes that unfold over time, understanding their temporal properties is of primordial importance. Consequently, the amount of studies devoted to emotion dynamics has strongly increased during the last decades (Kuppens, Stouten, & Mesquita, 2009). Many of these studies have inspected the duration of emotional episodes (e.g., Scherer, Wallbott, & Summerfield, 1986) and determinants thereof (e.g., Verduyn, Delvaux, Van Coillie, Tuerlinckx, & Van Mechelen, 2009).

Another branch of this research domain focuses on emotion intensity profiles. In a pioneering study, Sonnemans and Frijda (1994) showed that, irrespective of duration differences, the

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intensity course of an emotion over time, as recollected and drawn by participants, can vary hugely with respect to shape and amplitude (i.e., the height of the profile). A major challenge for emotion researchers is to capture and account for this variability (Frijda, 2007).

CAPTURING SHAPE AND AMPLITUDE DIFFERENCES AND THEIR RELATION TO DURATION

Up until now, two approaches have been used to describe shape and amplitude differences among emotional intensity profiles. Sonnemans and Frijda (1994) used features such as the intensity of the highest peak and the area underneath the profile. However, these features were selected ad hoc and, consequently, it remained unclear whether these were the only and best possible features to describe shape and amplitude variability.

To address this limitation, Verduyn, Van Mechelen, Tuerlinckx, Meers, and Van Coillie (2009) and Verduyn, Van Mechelen, and Frederickx (2012) more systematically inferred the relevant features by means of functional principal component analysis. For this purpose, they reconstructed the deviation of manifest intensity profiles from the average intensity profile by means of a weighted combination of latent profiles (components). To avoid that differences in duration rather than shape would drive the resulting component solution, duration differences were controlled by stretching all profiles to equal length. Consequently the relative timing of the profiles was studied. The obtained components, each reflecting a feature that describes shape and amplitude variability, were labelled as steepness at onset, skewness and number of peaks. Specifically, an episode that scores high on the first (and on average on the other components) corresponds to a profile with a steep onset whereas a low score indicates a less explosive start. High versus low scores on the second component relate to skew profiles that are especially intense in the second versus first half of the episode. Finally, a high score on the third component corresponds to a profile with multiple peaks and a low score to a profile with a single peak.

Whereas inferring the relevant features from manifest intensity profiles is appealing, a drawback of functional principal component analysis is that it confounds shape and amplitude differences. For example, profiles that score high versus low on steepness at onset have both a different shape (peak situated within the first vs. second half of the episode) and a different amplitude (high vs. low overall intensity). Moreover, in some cases intensity profiles that have very different component scores may actually have a similar shape while differing only in amplitude.

PREDICTING SHAPE, AMPLITUDE AND DURATION DIFFERENCES

Three central classes of predictors of intensity profile shapes and amplitudes have been examined in previous research, namely appraisals, emotion regulation strategies and dispositional factors (Verduyn et al., 2012). Regarding appraisals, high perceived importance of the emotion-eliciting event was found to be associated with explosive intensity profiles that become even more intense during the second half of the episode. Furthermore, for negative emotions it was observed that emotion-eliciting events with low controllability are associated with profiles reaching their peak during the second half of the episode. Regarding regulation strategies, rumination was found to lead to emotion reactivations resulting in multiple profile peaks. Moreover, rumination also appeared to intensify the emotion over time causing the highest peak to occur within the second half of the profile. Regarding dispositional factors, extraversion was positively related to steepness at onset, for positive emotions.

Though promising, these findings are limited as the number of predictors studied was rather low. This is especially the case for the category of regulation strategies, within which only rumination has been investigated. Yet, this category is much broader. For example, in the case of negative

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events, Garnefski, Kraaij, and Spinhoven (2001) differentiate between five adaptive strategies: positive reappraisal, positive refocusing, acceptance, focus on planning and putting into perspective; and four maladaptive strategies: catastrophising, rumination, blaming others and self-blame. Note that we adopt a hedonistic perspective on anger regulation, which implies that regulation strategies are considered adaptive when they decrease the unpleasant anger affect and maladaptive when they increase it (Bridges, Denham, & Ganiban, 2004; Larsen, 2000).

OVERVIEW OF THE PRESENT STUDY

A first aim of the present study is to describe variability in intensity profiles of anger episodes, separating variability in shape and in amplitude. To this end, we propose to use a different data-analytic method, called K-spectral centroid (K-SC) clustering (Yang & Leskovec, 2011). When applied to intensity profiles that are stretched to equal length, this method yields a clustering of the intensity profiles according to shape and a score reflecting the amplitude of the profiles. Based on the functional principal component analysis, we expect to find at least two clusters: a cluster of shorter-lasting profiles that reach a peak in the first half of the episode followed by a recovery period and a cluster of longer-lasting profiles with a peak in the second half of the episode preceded by a period of intensity accumulation. Regarding amplitude, we expect to find sizeable differences within each cluster which are positively related to duration (Sonnemans & Frijda, 1994).

The second aim of this study is to examine how a broad range of regulation strategies is related to the shape, amplitude and duration of anger intensity profiles. Regarding shape, we hypothesise that the maladaptive strategies within the Garnefski et al.'s framework will be related to profiles reaching a peak in the second half of the episode as these maladaptive strategies are assumed to strengthen intensity over time. In contrast, we expect the adaptive strategies, which are conjectured to stimulate emotional recovery (Garnefski et al., 2001), to relate to intensity profiles showing a peak in the first half of the episode followed by a recovery process. Regarding amplitude, we expect that, regardless of profile shape, the adaptive strategies will be negatively associated with the amplitude of the anger intensity profiles, and the maladaptive ones positively. This hypothesis links up with previous findings on the relation between these regulation strategies and overall negative emotion intensity (Bushman, 2002; Rude, Maestas, & Neff, 2007; Verduyn et al., 2012). Finally, we expect duration to be positively related to maladaptive regulation and negatively to adaptive regulation (Verduyn, Delvaux, et al., 2009; Verduyn, Van Mechelen, & Tuerlinckx, 2011).

We focused on a single negative emotion, namely anger, because it (1) was included in previous research on intensity profiles (Verduyn, Van Mechelen, et al., 2009; Verduyn et al., 2012), (2) is a negative emotion that is relatively frequently experienced (Scherer, 2005) and (3) is known to activate many emotion regulation strategies (Gross, Richards, & John, 2006). To obtain a wide range of anger intensity profiles, we asked participants to recall 12 specific episodes of anger, which varied with respect to event importance, causality and controllability.

METHOD

Participants

Participants were 95 psychology students of the University of Leuven (17 men and 78 women). Their mean age was 18.7 years (SD = 1.1). Participation was in partial fulfilment of a course requirement.

Materials and procedure

Participants were invited to the computer rooms of the university in groups of 30. The experimenter informed them that they would be asked to recall 12 anger episodes that were elicited by events that are characterised by specific combinations of importance, causality and controllability, draw the

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associated anger intensity profiles as accurately as possible, and answer a number of questions regarding each episode. As we were interested in the full-intensity course of emotional episodes, participants were asked to report only anger episodes that had already ended. The end was further defined as the point in time at which anger was no longer felt for the first time. If the emotional reaction to the anger-eliciting event was re-elicited later on, participants were asked to consider this as a new anger episode (Verduyn, Van Mechelen, et al., 2009; Verduyn et al., 2012).

The anger questionnaire was divided into 12 blocks, one for each kind of anger-eliciting event. The events resulted from crossing three event features, namely event importance (low or high), event causality (yourself, another person or no person) and event controllability (low or high). Block order was randomised between participants. Each block started with asking participants to recall a specific anger experience (e.g., an anger episode preceded by a low-importance event, caused by another person, and which the participant felt highly capable of controlling). Participants were asked to take sufficient time to recall the requested event. If they could not recall a relevant episode, they hit the "I cannot remember an event" button. If they remembered a relevant episode, they clicked the "I remember an event" button and responded to the following episode questions.

Appraisals

Participants were asked to briefly describe the emotion-eliciting event and to answer three appraisal questions to check whether the event met the manipulated appraisal requirements (i.e., manipulation check). In particular, participants were asked to indicate how important the event was (low or high), who caused it (yourself, other person or no person) and how much they could control it (low or high).

Regulation strategies

Next, participants scored the use of regulation strategies during the anger episode on an eight-point scale ranging from not at all (0) to very strong (7). In particular, the following questions were asked: While you were experiencing the emotion, to what extent did you think: (1) the situation also had positive sides (positive reappraisal), (2) of something nice instead of what happened to you (positive refocusing), (3) it was the fault of others (blaming others), (4) you should accept what happened (acceptance), (5) about how best to handle the situation (focus on planning), (6) that there are worse things in life (putting into perspective), (7) something terrible happened to you (catastrophising), (8) it was your own fault (self-blame) and (9) to what extent did you engage in thoughts and feelings on what happened (rumination).

Episode duration

Subsequently, participants had to estimate the duration of the episode, by indicating how many hours, minutes and/or seconds the episode lasted. Since sleeping interrupts emotional experience, the maximum duration was limited to 24 hours.

Intensity profile

Next, they were asked to draw as precisely as possible the intensity course of the emotion over time. For this purpose, a two-dimensional grid was presented. The Y-axis represented emotional intensity and was divided into six intervals with labels ranging from "no emotion" to "very high". The Y-coordinates were stored with a resolution of 375 pixels with the label "no emotion" corresponding to 0 and the label "very high" corresponding to 350. The X-axis represented the time dimension and ranged from 0 to a number that corresponded to the answer given on the duration question. The X-coordinates were stored with a resolution of 475 pixels. Specifically, the start of an episode is stored as time point 1 and the end as time point 475. The remaining 473 time points (2–474) are selected equidistantly over the entire duration of the episode. Thus, the shape differences in the resulting intensity profiles pertain to relative timing differences rather than absolute ones (see Verduyn, Van Mechelen, et al., 2009; Verduyn et al., 2012).

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Data analysis

To disentangle and summarise the shape and amplitude differences among the profiles, the collected intensity profiles were subjected to K-SC clustering (Yang & Leskovec, 2011), using 100 random starts, and with the number of clusters varying from 1 to 10. K-SC clustering groups profiles into K clusters according to their shape. These shape differences can be interpreted by examining the cluster centroids. Moreover, K-SC models amplitude differences within the clusters by providing an amplitude coefficient for each profile. More formally, the original profiles $\mathbf{x}_i$ are approximated as follows:

$$\mathbf{x}_i = \sum_{k=1}^{K} p_{ik} f_i \mathbf{b}_k$$

where p_{ik} is a binary score that indicates to which of the K clusters the ith profile belongs (with each profile belonging to a single cluster only), f_i is the amplitude coefficient for the ith profile and $\mathbf{b}_k$ is the cluster profile or centroid of cluster k.

Finally, we examined which emotion regulation strategies and appraisals predict profile shape (using logistic regression) and amplitude and duration (using linear regression). These analyses were run with each regulation strategy/appraisal acting separately as independent variable and with all of them included at once as independent variables.

RESULTS

Manipulation checks and number of collected intensity profiles

The agreement between the appraisal manipulations and the ratings provided by the participants was fair (88% for importance, 91% for cause and 86% for control). A possible reason for the lack of perfect agreement is that the appraisal of an emotional episode, which initially is remembered in a specific way, may change after writing down the situation and reflecting on it.

Participants reported a total of 586 anger intensity profiles. This implies that for the 12 manipulated appraisal patterns, on average 51% of the participants could recall an instance of the pattern under study. Furthermore, this percentage varied across the 12 patterns, although each of the patterns was reported by a sufficiently high percentage of participants. Specifically, out of the 95 participants 47% reported low importance-yourself-low control events, 47% low importance-yourself-high control events, 58% low importance-other person-low control events, 53% low importance-other person-high control events, 57% low importance-no person-low control events, 38% low importance-no person-high control events, 48% high importance-yourself-low control events, 58% high importance-yourself-high control events, 76% high importance-other person-low control events, 57% high importance-other person-high control events, 55% high importance-no person-low control events and 23% high importance-no person-high control events.

Shape, amplitude and duration differences

Profile shape

Using K-SC clustering we examined how many prototypical shapes (clusters) can be discerned in the intensity profiles. On the basis of a goodness-of-fit versus number-of-clusters plot, we decided to retain a two-cluster solution. The associated cluster centroids are displayed in Figure 1, with the X-axis displaying relative time. The shapes of these centroids confirm our expectations. Indeed, the cluster centroid of the first cluster, to which 284 (48%) intensity profiles were assigned, shows an intensity profile with a peak situated at the beginning, followed by a process of recovery. In contrast, the cluster centroid of the second cluster, to which 302 (52%) intensity profiles belong, reveals an intensity profile with a peak occurring

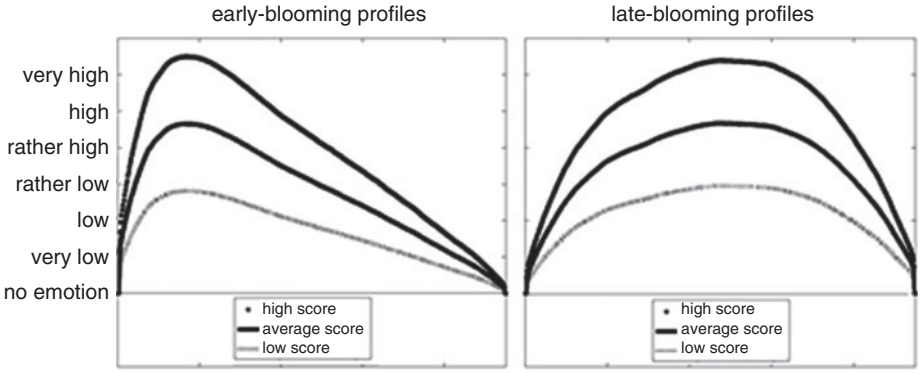

Figure 1. *Reconstructed intensity profiles obtained through K-SC analysis.*

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relatively late in the episode, preceded by a period of intensity accumulation. In the remainder of this paper, we will refer to these clusters as early-blooming (first cluster) and late-blooming episodes (second cluster).[1]

Profile amplitude

In Figure 1, we visually illustrate the estimated amplitude differences within each of the two clusters by drawing the profiles that are obtained for a mean amplitude coefficient (full line) and for coefficients one standard deviation below and above this mean value (dashed lines). It can be concluded that within each cluster sizeable variability in amplitude was observed.[2] Conducting an analysis of variance (ANOVA) with cluster membership as independent variable and maximum intensity level of the reconstructed profile as dependent variable, no evidence was found for a relation between shape and amplitude, $F(1, 584) = 0.01$, $p = .92$. Note that we use the maximum intensity level of the reconstructed profile rather than the amplitude scores, because amplitude scores of profiles belonging to different clusters cannot be meaningfully compared.

Profile duration

The reported episodes differ substantially in duration,[3] with the first, second and third quartiles amounting to 20, 45 and 150 minutes. These duration differences are significantly related to shape, $F(1, 584) = 15.28$, $p < .001$, as well as amplitude ($r = 0.31$, $p < .001$). Late-blooming emotions last longer and the longer the episode, the higher its maximal intensity.

Predictors of shape, amplitude and duration

In a next step we examined the extent to which the regulation strategies and appraisals predict the shape, amplitude and duration of the anger intensity profiles. Note that the manipulated appraisals were used as predictor variables in all analyses. When replacing these by the reported appraisals, however, essentially the same results were found.[4]

[1] We did not find evidence for a relation between cluster membership and gender ($\chi^2 = 0.11$, $p = .83$).

[2] No evidence was found for a relation between amplitude and gender ($F(1, 584) = 0.003$, $p = .96$).

[3] For duration, too, no significant relation with gender was found ($F(1, 584) = 0.51$, $p = .48$).

[4] In addition, rated low control over the emotion-eliciting event was also found to relate significantly to a higher amplitude and a longer duration.

Table 1. *Regression weights of the regulation strategies and appraisals, when predicting shape (separate logistic regression for each strategy and each appraisal, with early-blooming coded as 0 and late-blooming as 1), amplitude and duration (separate linear regressions). For the appraisal categories, low-importance, yourself as cause, another person as cause and low control were coded as 1*

		Shape	*Amplitude*	*Duration*
Adaptive regulation	Positive reappraisal	−0.10*	−13.34*	−0.30*
	Positive refocusing	−0.06	−17.34*	−0.39*
	Accepting	−0.08	−13.78*	−0.10
	Focusing on planning	−0.02	−4.50*	−0.02
	Putting in perspective	−0.19*	−12.54*	−0.44*
Maladaptive regulation	Catastrophising	0.14*	19.76*	0.85*
	Rumination	0.09*	16.09*	0.58*
	Blaming others	0.05	6.82*	−0.04
	Self-blame	−0.03	1.62	0.02
Appraisals	Importance: low	−0.66*	−71.18*	−2.57*
	Cause: yourself	−0.05	10.79	−0.02
	Cause: other person	0.20	23.84*	−0.40
	Control: low	−0.00	13.56	0.57

Note: *$p < .05$.

Profile shape

The results of simple logistic regression analyses with shape as dependent variable and one regulation strategy/appraisal as independent variable are presented in Table 1. With respect to regulation, early-blooming episodes are associated with adaptive strategies such as positive reappraisal and putting in perspective. In contrast, late-blooming episodes are associated with maladaptive strategies such as catastrophising and rumination. With respect to appraisals, high-importance events are more often followed by late-blooming episodes, whereas events low in importance typically gave rise to early-blooming episodes. Causality and control were not significantly related to profile shape.

A multiple logistic regression including all regulation strategies and appraisals that appeared to be significant predictors of shape in the simple regressions as predictor variables, revealed that putting in perspective uniquely contributes to the odds of having an early-bloomer shape ($B = -0.156$, $p < .005$).

Profile amplitude

From simple regression analyses with amplitude as dependent variable and one regulation strategy/appraisal as independent variable, evidence for the expected negative relation between profile amplitude and all adaptive strategies was found. Moreover, as hypothesised, profile amplitude positively related to three of the maladaptive strategies (catastrophising, rumination and blaming others). Regarding appraisals, amplitude was positively related with higher event importance and with the cause of the event being another person. Finally, a multiple linear regression including all regulation strategies and appraisals that appeared to be significant predictors of amplitude in the simple regression analyses as predictor variables, revealed unique contributions of positive refocusing, $B = -6.70$, $t(574) = -2.99$, $p < .005$; accepting, $B = -5.26$, $t(574) = -0.94$, $p < .01$; catastrophising, $B = 11.07$, $t(574) = 5.78$, $p < .001$; rumination, $B = 5.29$, $t(574) = 2.66$, $p < .01$; and importance, $B = -33.00$, $t(574) = -4.60$, $p < .001$.

Profile duration

Results from simple regression analyses with duration as dependent variable and one regulation strategy/appraisal as independent variable (Table 1) show that the reported duration is shorter when participants used positive reappraisal, positive refocusing or putting into perspective, and longer

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when catastrophising or rumination were adopted, or when the eliciting event was appraised as highly important. A multiple linear regression including all regulation strategies and appraisals that appeared to be significant predictors of duration in the simple regressions as predictor variables, revealed unique contributions of catastrophising, $B = 0.60$, $t(579) = 5.34$, $p < .001$, and importance (leading to longer emotions; $B = -1.17$, $t(579) = -2.74$, $p < .01$).

DISCUSSION

Anger is typically perceived as a short-lasting emotion with an explosive onset (Frijda, 2007). The current study provides support for the existence of this prototypical anger profile as half of the intensity profiles reflected an early-bloomer shape and lasted relatively short. However, in addition to this more traditionally expected pattern, our findings revealed another prototypical anger intensity profile with a late-bloomer shape. In these episodes, intensity accumulates over a sizeable amount of time—the episodes lasted longer and reached their peak relatively late. Thus, the present study adds to the literature on anger categorisation, where often a difference is made between cold and hot anger (e.g., Scherer et al., 1986). Our categorisation differs from the hot–cold distinction in that the former is primarily based on duration and regulation differences and the latter on the underlying appraisal patterns and expressive behaviour (e.g., prosody). A possible relationship between both categorisations cannot be excluded based on the present data, however. To shed light on this issue, future research assessing emotion expression in addition to appraisals, regulation and temporal profiles is needed.

On average, early- and late-blooming episodes do not differ in terms of amplitude. Yet, within each of the two groups of episodes considerable differences in amplitude show up, implying that not all early-bloomers are equally explosive and that not all late-bloomers build up to an equally extreme boiling point.

The regulation strategies adopted play a critical role in these shape, amplitude and duration differences; for all three types of differences some of these strategies also have unique predictive contributions. Specifically, early-bloomers were associated with reappraisal and putting into perspective, whereas late-bloomers were related to catastrophising and rumination. This finding confirms previous research showing that reappraisal and putting into perspective are effective strategies to cope with negative emotions, whereas catastrophising and rumination are ineffective in this regard (Gross, 1998; Koole, 2009; Verduyn et al., 2012). Second, all adaptive strategies were negatively related to amplitude and almost all maladaptive strategies positively (the exception being "self-blame"). Linking up with previous research (Ray, Wilhelm, & Gross, 2008; Rusting & Nolen-Hoeksema, 1998), this confirms that regulation strategies may cause an overall shrinking or expanding of an anger experience. Finally, positive reappraisal, positive refocusing and perspective taking were negatively related to duration and catastrophising and rumination positively. The combination of these results extends previous research by pinpointing the role of the different strategies in the temporal pattern of an anger experience: Positive reappraisal and putting into perspective prevent intensity from accumulating, stimulate recovery, dampen overall intensity and shorten the emotions, whereas rumination and catastrophising further intensify the emotion over time and prolong it.

Regarding appraisals, event importance was found to have a unique predictive contribution to amplitude and duration differences. Amplitude was higher when the preceding event was highly important, thus confirming previous research on the event importance–intensity relationship (Sonnemans & Frijda, 1995). Also in line with earlier findings (e.g., Verduyn, Van Mechelen, et al., 2009), emotional episodes that are elicited by an event that is perceived as highly important, last longer.

Limitations and future research

A first limitation of the current study is that we focused on one negative emotion only, namely

anger. Future studies are needed to examine whether our results generalise to other negative emotions. Moreover, it would also be interesting to inspect positive emotions, as this could lead to new insights into the temporal processes underlying the savouring and dampening of such emotions (Quoidbach, Berry, Hansenne, & Mikolajczak, 2010; Tugade & Fredrickson, 2007).

Second, we did not study whether other emotions occurred during or after the reported episode. For instance, due to regulation, the anger experience may have transformed into another emotion. To study such transformations in future research, one may use a valence–arousal-based affect grid (Russell, Weiss, & Mendelsohn, 1989) and investigate the effect of regulation on location changes in this grid across time.

Third, a disadvantage of retrospective studies is that they may be prone to memory biases, although we tried to avoid them by asking participants to take sufficient time to remember how they felt and thought during the episode and by evoking the context of the emotional episode (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004).[5] We selected this data gathering method, because we wanted to collect data on a wide range of anger episodes that cannot all be easily elicited in a laboratory environment and that do not occur on a daily basis, which precludes the use of online and end of the day methods.

Finally, the current sample consisted of young adults only, which were mainly female. Future studies need to examine whether the obtained findings also generalise to different populations.

CONCLUSION

In the current study, two prototypical shapes of anger intensity profiles have been identified: early-bloomers and late-bloomers. Early-bloomers are relatively short emotional episodes that reach their peak immediately following the emotion-eliciting events. These profiles are typically associated with a low-importance event and adaptive regulation. Late-bloomers are relatively long-lasting emotional episodes that reach their peak only after a period of intensity accumulation. These profiles are related to high-importance events and maladaptive regulation. Overall amplitude as well as duration is positively associated with the importance of the eliciting event and the use of maladaptive regulation strategies and negatively associated with the use of adaptive regulation strategies.

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[5] Still, we cannot exclude that the appraisals that were actually experienced differ from how participants remember them, because participants will have digested the emotional event meanwhile.

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