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A Computational Model of the Relation between Regulation of Negative Emotions and Mood

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Abstract. In this paper a computational model is presented that describes the role of emotion regulation to reduce the influences of negative events on long term mood. The model incorporates an earlier model of mood dynamics and a model for the dynamics of emotion generation and regulation. Example model simulations are described that illustrate how adequate emotion regulation skills can prevent that a depression is developed.

Keywords: depression, emotion regulation, mood regulation, agent.

1 Introduction

Emotions were traditionally seen as a neural activation states without a function[1]. However, relevant research provides evidence that emotions are functional [2, 3] and provide information about the ongoing fight between a human being and its environment[4]. In addition to the theories that exist in social psychology also in recent neurological literature many contributions (e.g.,[2, 4]) can be found about the relation between emotion and brain functioning. For example, emotional responses relate to activations in the brain within the limbic centers (generating emotions), and cortical centers (regulating emotions); cf.[5, 6]. Previously emotions were often left out of cognitive models; however since the awareness that emotions play a vital role in human lifes is increasing, cognitive models are developed that include the generation and regulation of emotions as well. A useful basic theory for the latter is the one of Gross: on how individuals regulate which emotions they have, when they have them and how they experience and express them[7].

Emotions are different from mood, and emotion regulation is different from mood regulation[7, 8]. Emotions are instantaneous in nature and are specific reactions to a particular event, usually for a short period of time. Emotions help us to set priorities in our lives, taking initiatives in changing situations or making decisions based on how we feel, whether we are happy, angry, frustrated, bored or sad. Emotion regulation describes how a subject can use specific strategies to affect the emotion response levels. Mood, on the other hand, is a more general feeling such as happiness, sadness,

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frustration, or anxiety that exists for a longer period of time. Mood regulation usually involves the deliberate choice of mood-affecting activities, such as pleasant activities[9]. It has been found that recurring events triggering stressful emotions have a bad influence over time on mood and can easily lead to depression when subjects are vulnerable for that [10, 11].

In this paper a computational model is introduced that combines the short-term emotional reaction on stressful events with the long term dynamics of mood. The model is based on existing model for mood dynamics[12] and the theory for emotion regulation introduced by Gross [7, 8, 13]. In the current paper, it is shown how this process of emotion regulation can help people to maintain a healthy mood in case of the occurrence stressful events.

The paper is organized as follows. First, in Section 2 some background information about the mood model and the process of emotion regulation is presented. In Section 3 the integrated model is explained in detail. In Section 4 simulation results are provided to show the influence of stressful events in different scenario's, thereby providing evidence for the feasibility of the model. Finally, Section 5 concludes the paper.

2 Background on Emotion Regulation and Mood Dynamics

The model presented in this paper adopts Gross' theory of emotion regulation and an existing model of mood dynamics[12]. Both elements are introduced here briefly.

2.1 Emotion Regulation

Controlling emotions or regulating them is often related with the suppression of an emotional response, for example, expressing a neutral poker face. This kind of regulating emotions is sometimes considered not very healthy, and a risk for developing serious kinds of medical problems. However, it has been found that the strategies to regulate emotions are much more varied. For example, closing or covering your eyes when a movie is felt as too scary, or avoiding an aggressive person are other forms of emotion regulation mechanisms[13, 14].

The framework introduced by Gross describes how emotions can be regulated or controlled in different phases of the process during which emotions are generated[7]. Gross distinguishes cognitively regulated emotions, which occurs relatively early on in the emotion generation process (e.g., re-interpretation) and behaviorally regulated emotions, that happen relatively late in the emotion generative process (e.g., suppression).

Over a longer period of time several strategies for emotion regulation have been described in the literature. In general they are classified into two major categories. The first category covers the antecedent focused strategies that can be used before an emotional response has an effect on the behavior. In this category of emotion regulation, emotions may be regulated at four different points in the emotion generation process (a) selection of the situation, (b) modification of the situation, (c) deployment of attention, (d) change of cognition. The second category is formed by the response focused strategies, which can be used in situations where the emotion response already is coming into effect; this is also called modulation of responses[7]. In the current paper the focus is on antecedent focused strategies, in particular re-interpretation of world information by belief change.

2.2 Modeling Emotion Regulation

Based on the theory of emotion generation and regulation described above, a computational model of emotion regulation has been introduced before [15] and applied in the context of contagion and decision making. A detailed discussion of this model is given in that paper; however, here a brief summary is given of these concepts and their dynamics. As illustrated in the dashed box in the upper part of Fig.1 the following concepts play their part in the model: control state (cs), beliefs (bel), feeling (feel), preparation (prep), and sensory representation (srs(x)). The aim of the model is to describe how negative beliefs and feelings are generated and how alternative, more positive beliefs can be generated to regulate the negative feeling. The model is inspired from various neurological theories [16–19] , from fMRI experiments it has been found that emotion regulation occurs through the interaction between prefrontal cortex and amygdala. Here less interaction or weak connections between amygdala and prefrontal cortex lead to less adequate emotion regulation[16].

In the model, antecedent focused emotion regulation is achieved by the interplay of three states cs(b, c), bel(c), feel(b). Negative weights are assigned to the connections from the control state cs to negative beliefs bel(c) and negative feelings feel(b). Positive weights are assigned to connections in the opposite direction. In the example scenario only two beliefs are taken into account: a positive belief which may associate to good feeling and a negative belief which is related to a stressful feeling (actually for the sake of simplicity there is only one negative feeling state in the scenario). A control state is used to determine whether an unwanted emotion through a negative belief has occurred (as a form of monitoring as happens in the prefrontal cortex). If so, by becoming activated the control state suppresses these negative effects. Furthermore, as they concern opposite interpretations of the world information, both beliefs inhibit each other, which is modelled by assigning negative weights to their mutual connections. In the literature (e.g.,[20]) emotion generation and emotion regulation are sometimes considered as overlapping in one process.

In the model introduced here on the one hand both subprocesses (emotion generation and regulation) are clearly distinguished but on the other hand by the cyclic connections between them and the dynamics created by these cycles the processes are fully integrated into one process.

The sensory representation srs(w) of a world state w is associated both with a negative and a positive belief, as a basis for two different interpretations of the same world information;, as discussed earlier they suppress each other by a form of inhibition. Only the negative belief has a connection with the preparation for a negative emotional response prep(b). The feeling state feel(b) has an impact on this preparation state prep(b), which in turn has an impact on feeling state feel(b) through srs(b) which makes it recursive; this is often called an as-if body loop in the literature (e.g.,[2]).

2.3 Modeling Mood Dynamics and Depression

The model of mood dynamics is depicted in Fig. 1 (lower part). The main concepts include the *mood level*, *appraisal* and *coping skills* of a person, and how the levels for these states affect the external behavior in the form of selection of situations over time (*objective emotional value of situation*). The model is based upon a number of psychological theories, see [12] for a mapping between the literature and the model itself.

In the model, a number of states are defined, whereby to each state at each point in time a number on the interval [*0,1*] is assigned. First, the state *objective emotional value of situation* represents the value of the situation a human is in (without any influence of the current state of mind of the human). The state *appraisal* represents the current judgment of the situation given the current state of mind (e.g., when you are feeling down, a pleasant situation might no longer be considered pleasant). The *mood level* represents the current mood of the person, whereas *thought* indicates the current level of thoughts (i.e., the positivism of the thoughts). The *long term prospected mood* indicates what mood level the human is striving for in the long term, whereas the *short term prospected mood level* represents the goal for mood on the shorter term (in case you are feeling very bad, your short term goal will not be to feel excellent immediately, but to feel somewhat better). The *sensitivity* indicates the ability to select situations in order to bring the *mood level* closer to the *short term prospected mood level*. *Coping* expresses the ability of a human to deal with negative moods and situations, whereas *vulnerability* expresses how vulnerable the human is for negative events and how much impact that structurally has on the mood level. Both *coping* and *vulnerability* have an influence on all internal states except the prospected mood levels, but in Figure 1, those arrows are left out for clarity reasons. Finally, *world event* indicates an external situation which is imposed on the human (e.g., losing your job).

3 Integrated Model

The integrated model describes how the emotion generation and regulation mechanism influences the mood dynamics. It describes how specific stressful events generate specific instantaneous negative feelings, which have a negative effect on the (subjective) appraisal (also called sevs – subjective emotional value of the situations of the person) of the more general situations of the person and thus on the mood. When emotion regulation is taking place, the instantaneous feelings will be less negative and thus reduce the influence of the stressful events on the mood. To implement this principle in the model, a connection from the negative feeling in the regulation model to appraisal state in the mood model is introduced. The purpose of this connection is to model the effect of negative but short term feelings on the (longer term) mood. In the model, only negative feelings are considered. For beliefs, there is both a positive and a negative variant. The world(w), sensor(w), srs(w) states may lead to the negative and positive belief as alternative interpretations of the same world information.

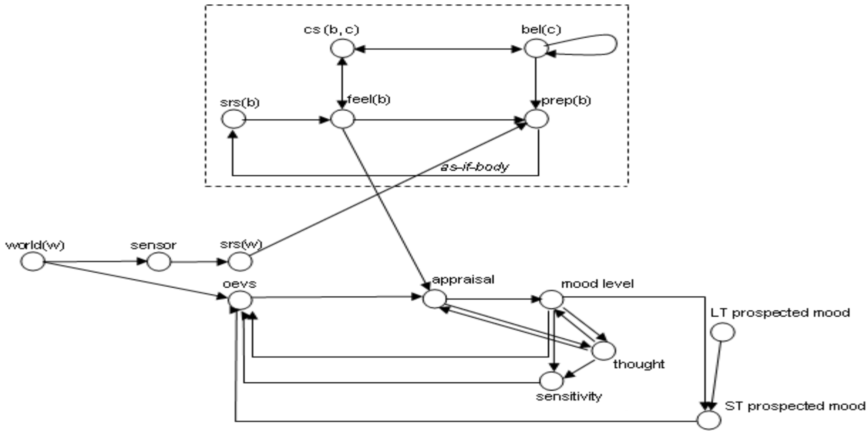

Fig. 1. The integrated model: emotions about stressful events and their influence on mood

4 Simulation Results

In this section, example simulation results are presented that show how emotion regulation can help to change bad beliefs and feelings into more positive beliefs and feelings, and thus protects the mood against stressful events. First, some details of the model design and its implementation and the parameter values used are described.

As mentioned, for the model of mood dynamics (the lower part of Fig. 1) an existing model is used. Due to the lack of space, we have to refer to original article [12] for the numerical details of this part of model.

In the emotion regulation model, the activation level of a state is determined by the impact of all the incoming connections from other states thereby being multiplied by their corresponding connection weights. In the simulations, the connection weights set at the following values: $w_{worldstate\_sensor}$ 1.0,$w_{sensor-srsw}$ 1.0, $w_{srsw-PosBel}$ 0.4, $w_{srsw-NegBel}$ 0.9, w_{NegBel_prep} 0.9, w_{Prep_srsb} 0.9, w_{srsb_feel} 0.9, w_{feel_prep} 0.4, w_{cs_feel} -0.2, w_{cs_negBel} -0.35, w_{NegBel_PosNeg}= -0.3, $w_{PosNeg\ \_\ NegBel}$= -0.1. When no emotion regulation takes place w_{feel_cs} and w_{negBel_cs} are taken 0. For scenarios in which emotion regulation takes place, the value of w_{feel_cs} and w_{negBel_cs} change from 0 to 3 and 0.05.

In particular, for a state causally affected by multiple other states, to obtain their combined impact, first the activation levels V_i for these incoming state are weighted by the respective connection strengths w_i thus obtaining X_i=$w_i v_i$ and then, these values X_i are combined, using a combination function $f(X_1,.., X_n)$. In the context of emotion regulation model, the combination function is based on the following function:

$$V_{new} = V_{old} + adapt_{ER} * th(\tau, \sigma, X_1+X_2+\ldots+X_n)$$

Where $adapt_{ER}$ is an adaptation factor, determines the speed with which the value of state changes. The $adapt_{ER}$ for all states of the emotion regulation model is equal to 6. And,

$$th(\tau, \sigma, X) = \left(\frac{1}{1 + e^{-\sigma(X-\tau)}} - \frac{1}{1 + e^{-\sigma\tau}}\right)(1 + e^{-\sigma\tau})$$

The following table shows the value of σ and τ for each state:

Table 1. Parameter values used in the simulation of emotion regulation model

	NegBel	PosBel	prep	srs	feel	cs
τ	9	9	4	3	5	4
σ	0.1	0.1	0.4	0.2	0.10	0.5

4.1 Simulation of the Emotion Regulation Mechanism

The aim of this first simulation is to show the effect of emotion regulation on beliefs and negative feelings. In this experiment, it is assumed that a bad event happened for 3.3 hours. In this case, there are two different beliefs about this event, a negative and one positive one (for example, after losing a match, negative belief is that you played awfully and blame yourself, and positive belief is that your rival was much more powerful and the stadium was full of his fans).

Fig. **3** shows the results of this simulation. As can be seen, when no emotion regulation takes place (Fig. **3**a), the negative event dominates and it leads to a high value of negative feeling. However, when the emotion regulation does take place (Fig. **3**b), the generated negative belief and negative feelings lead to the activation of the control state, and consequently it causes weakening of the negative belief and due to this the positive belief can become dominant. Eventually, activation of the control state also decreases the value of negative feeling (purple line). This substantially reduces the effect of the negative feeling: it can be seen that the integral of the area below the feeling is 2.3 times smaller than in the upper graph.

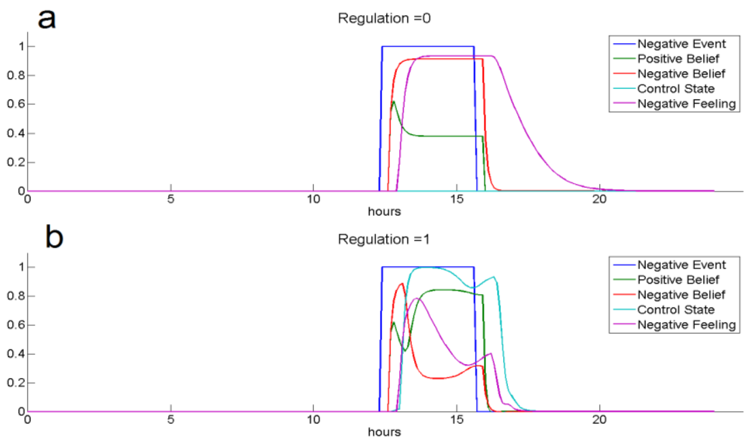

Fig. 2. Simulation results of emotion regulation model when a bad event happens. a) without emotion regulation b) with emotion regulation.

4.2 Simulation of the Mood

The integrated model was used to simulate three types of persons in different situations. The different types are characterized by different values for the parameters *coping*, *vulnerability* and *LT prospected mood level*. The first type of person is an *emotionally stable person*, defined by having good coping skills that balance out any vulnerability and by having the desire to have a good mood: coping is 0.5, vulnerability 0.5 and LT prospected mood level 0.8. An *emotionally slightly unstable person* is defined by having some vulnerability and bad coping skills and the desire to have a medium mood: settings 0.1, 0.9 and 0.6 respectively. The third type, an *emotionally very unstable person*, is characterized by settings 0.01, 0.99 and 0.6. As start value for OEVS the equilibrium state is used; this needs to be calculated for each type so that when no events occur, the person stays balanced with al variables equal to LT prospected mood level. For type the OEVS is 0.8, for type 2 it is 0.94 and for type 3 the stable OEVS is 0.999.

The six weights between mood, thoughts and appraisal can also be varied to simulate different personal characteristics. However, in these simulations they have been set at the following values: $w_{appraisal\_mood}$ 0.7, $w_{thoughts\_mood}$ 0.3, $w_{appraisal\_thoughts}$ 0.6, $w_{mood\_thoughts}$ 0.4, $w_{mood\_appraisal}$ 0.5, $w_{thoughts\_appraisal}$ 0.5. In each iteration, the value of each state(V_{new}) in the mood model is defined according the weighted sum of its inputs and its old value(V_{old}):

$$V_{new} = V_{old} + adapt_{mood} * (w_1V_1+W_2V_2+..)$$

The adaptation factor for all states in the mood model is 0.1. By comparing the adaptation factors of the mood model and the emotion regulation model, we see that the states of the emotion regulation model are updated 60 times faster than the states of the mood model. This is in line with the background provided in the introduction, which says that the emotions are much more short-time events than mood.

In **the first scenario,** three short (3.3 hours) bad events occur with the time interval of 12 hours. The length of the scenario is three weeks (504 hours). Table 2 shows the value of mood after one, two and three weeks, and the minimum value of mood, for each person when the emotion regulation is on or off.

Table 2. Simulation results when three bad events happen

	Person 1		Person 2		Person3	
	Without ER	With ER	Without ER	With ER	Without ER	With ER
Week 1	0.79008	0.78098	0.43627	0.50024	0.32473	0.39851
Week 2	0.80356	0.79827	0.45075	0.50162	0.27910	0.32961
Week 3	0.79825	0.80059	0.46553	0.50530	0.24847	0.28355

As Table 2 shows, a stable person does not require emotion regulation to handle these bad events (the value of mood does not change significantly when emotion regulation is on or off). However, emotion regulation is critical for person 2 (unstable). In fact, if emotion regulation does not take place, he/she will become depressed after these bad events (a depression is defined as a mood level below 0.5 during at least 336 hours (two weeks)[21]); while if emotion regulation does take place, the value of the mood will not go below 0.5 during this simulation. In contrast, the

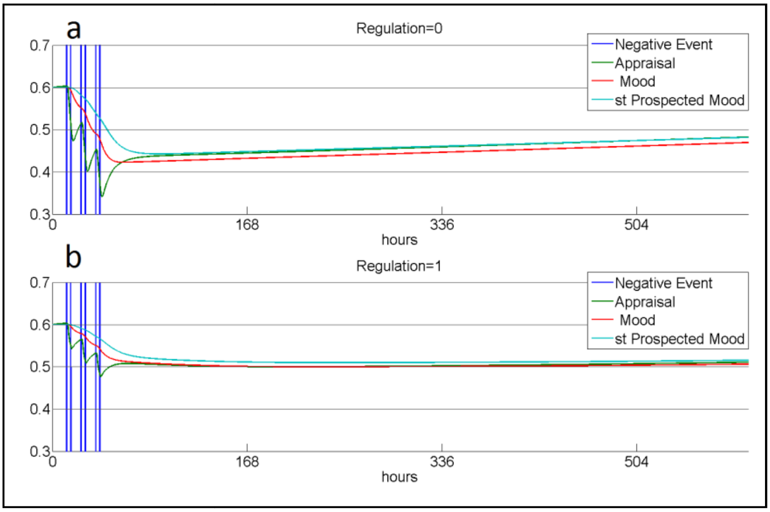

Fig. 3. Simulation results of first scenario for person with unstable characteristics. a) without emotion regulation b) with emotion regulation

emotion regulation does not save a very unstable person from depression. However, even in this case, the emotion regulation postpones the starting point of depression (time which the value mood become less than 0.5) for almost one day (22.8 hours).

Fig. 4 shows the results of the simulation of the first scenario for an unstable person. When ER is off (Fig. **4**a) events lead to a depression. While ER is ON (Fig. **4**b), it decreases the effect of negative events and saves the person from depression.

In **the second scenario**, bad events occur every 3 weeks in one year. Table 3 shows the minimum, average and maximum value of mood in last 3 weeks of this simulation for each person.

Table 3. Simulation results when bad events happen every 3 weeks during one year

	Person 1		Person 2		Person3	
	Without ER	With ER	Without ER	With ER	Without ER	With ER
Minimum	0.7607	0.7817	0.4414	0.4802	0.01060	0.0350
Average	0.7928	0.7914	0.4656	0.4899	0.01443	0.0437
Maximum	0.8017	0.8002	0.4893	0.5014	0.02052	0.5959

Fig. 5 shows the results of this simulation for unstable person. As it can be seen, after each bad event the person tries to recover his situation. However, if ER is off, the mood will not raise to 0.5. In contrast, when ER is ON, after each bad event, moods fall to below 0.5 and again recover to a value higher than 0.5.

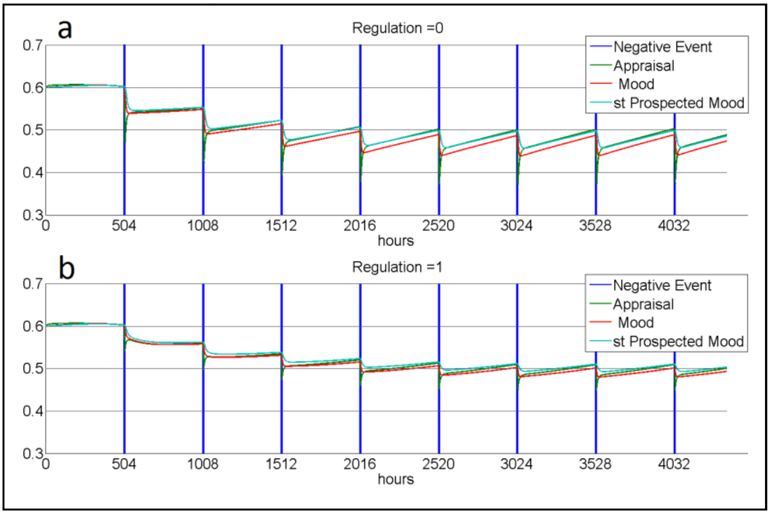

Fig. 4. Simulation results of the second scenario for person with unstable characteristics. a) without emotion regulation b) with emotion regulation

5 Discussion

In this paper, a computational model has been presented for the effect of emotion regulation (cf. [7]) on long term dynamics of mood. This model was used to analyze (by performing simulation experiments) the effect of emotion regulation on the mood level of people with different characteristics. The example simulation results presented have shown how the emotion regulation can prevent the depression in unstable persons, and postpone it in very unstable persons. This is in line with literature addressing the effect of stressful events on depression, such as [10] and [11]

In future work, a focus will be on modeling the effect of learning emotion regulation, i.e., to learn to generate positive beliefs about different events. Such learning can be supported, for example, by training in real or virtual training environments.

References

1. Hebb, D.O.: The organization of behavior: A neuropsychological theory. Psychology Press (2002)
2. Damasio, A.: The feeling of what happens: Body Emot. Mak. Conscious. Vintage, Lond (2000)
3. Oatley, K., Johnson-Laird, P.N.: Towards a cognitive theory of emotions. Cogn. Emot. 1, 29–50 (1987)
4. Schwarz, N., Clore, G.L.: Mood, misattribution, and judgments of well-being: Informative and directive functions of affective states. J. Pers. Soc. Psychol. 45, 513 (1983)
5. Papez, J.W.: A proposed mechanism of emotion. Arch. Neurol. Psychiatry 38, 725–743 (1937)

6. Dalgleish, T.: The emotional brain. Nat. Rev. Neurosci. 5, 583–589 (2004)
7. Gross, J.J.: The emerging field of emotion regulation: An integrative review. Rev. Gen. Psychol. 2, 271 (1998)
8. Gross, J.J.: Emotion regulation in adulthood: Timing is everything. Curr. Dir. Psychol. Sci. 10, 214–219 (2001)
9. Cuijpers, P., Van Straten, A., Warmerdam, L.: Behavioral activation treatments of depression: A meta-analysis. Clin. Psychol. Rev. 27, 318–326 (2007)
10. Kessler, R.C.: The effects of stressful life events on depression (1997)
11. Monroe, S.M., Harkness, K.L.: Life stress, the " kindling" hypothesis, and the recurrence of depression: Considerations from a life stress perspective. Psychol. Rev. 112, 417 (2005)
12. Both, F., Hoogendoorn, M., Klein, M.C., Treur, J.: Modeling the Dynamics of Mood and Depression. In: ECAI, pp. 266–270 (2008)
13. Gross, J.J.: Emotion regulation: Affective, cognitive, and social consequences. Psychophysiology 39, 281–291 (2002)
14. Goldin, P.R., McRae, K., Ramel, W., Gross, J.J.: The neural bases of emotion regulation: Reappraisal and suppression of negative emotion. Biol. Psychiatry 63, 577 (2008)
15. Manzoor, A., Treur, J.: Modelling the Role of Emotion Regulation and Contagion in Socially Affected Decision Making. Procedia-Soc. Behav. Sci. 97, 73–82 (2013)
16. Kim, M.J., Loucks, R.A., Palmer, A.L., Brown, A.C., Solomon, K.M., Marchante, A.N., Whalen, P.J.: The structural and functional connectivity of the amygdala: From normal emotion to pathological anxiety. Behav. Brain Res. 223, 403–410 (2011)
17. Phelps, E.A., Delgado, M.R., Nearing, K.I., Le Doux, J.E.: Extinction learning in humans: Role of the amygdala and vmPFC. Neuron 43, 897–905 (2004)
18. Sotres-Bayon, F., Bush, D.E., LeDoux, J.E.: Emotional perseveration: An update on prefrontal-amygdala interactions in fear extinction. Learn. Mem. 11, 525–535 (2004)
19. Yoo, S.-S., Gujar, N., Hu, P., Jolesz, F.A., Walker, M.P.: The human emotional brain without sleep—a prefrontal amygdala disconnect. Curr. Biol. 17, R877–R878 (2007)
20. Gross, J.J., Barrett, L.F.: Emotion Generation and Emotion Regulation: One or Two Depends on Your Point of View. Emot. Rev. 3, 8–16 (2011)
21. American Psychiatric Association et al.: Diagnostic and statistical manual of mental disorders, 4th edn. Am. Psychiatry. Assoc., Washington, DC (1994)