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How Motivated Are You? A Mental Network Model for Dynamic Goal Driven Emotion Regulation

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Abstract. Emotions drive our lives in one direction or another. It not only defines our psychological health but also shades light on one's goals in the external world. This paper introduces a mental network model to demonstrate how motivation states go together with emotion goals and goals in external world. The network model also deals with the variation in choice of strategies for regulating emotions to achieve the emotion goals. Moreover, it elaborates one example where anger, being a negative emotion, proves to be the right emotion goal to achieve goals in the external world. Simulation results are reported for the example scenario whereby the priority of emotion goals vary with the dynamic context.

Keywords: Emotion regulation · Emotion goals · Distraction · Rumination · Motivation · Anger · Adaptivity

1 Introduction

Emotions are considered as an adaptive response which helps in coping with the threats in the environment and demands of the situation (Frijda 1988; Izard 2009). Its regulation takes place by a causal path through motivation (Tamir et al. 2019) which means that a person must first get enough motivation to regulate his emotions. Moreover, activation of pre-hedonic goals are also considered to be as effective in downregulating negative emotions as could be the means for pursuing those emotions (Tamir et al. 2019). Activation of emotion goals automatically triggers the strategies and means that one already has at his/her disposal for changing one's emotions (Fishbach and Ferguson 2007). Emotion goals are considered as a "causal factor in emotion regulation" (Tamir 2016; Tamir and Millgram 2017). Goals and means are essential for each other to be pursued and emotion regulation strategies can independently affect emotion regulation in different ways. It's context that defines the efficacy of specific emotions i.e. each of the pleasant or unpleasant emotions can be beneficial in specific context (Izard 1990; Keltner and Gross 1999). This also means that a person can be motivated to increase his unpleasant emotions for achieving some goals such as anger in case of confrontational tasks (Tamir et al. 2008; Tiedens 2001). Moreover, the implications of anger are also dependent upon the context in which it's felt (Bonanno 2001).

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Goals are defined as the end results that people want to achieve from self-regulation (Gollwitzer and Moskowitz 1996; Thrash and Elliot 2001) and emotion goals are, therefore, defined as the emotion states that people aim at achieving while undergoing emotion regulation (Mauss and Tamir 2014; Tamir 2016). While undergoing emotion regulation, people aim at increasing or decreasing their emotions and for that they need to select some emotion regulation strategies (Gross 2015) as a mean to change their emotional experiences (Gross 1998).

A huge body of literature can be found about goals, emotions, motives and emotion regulation and their interactions. Thus, an important question is how these are related to each other and how they work together in different contexts. To investigate this computationally in a detailed manner, a dynamic modeling approach is required, where the dynamic (and cyclic) interaction between different mental states can be addressed in order for the person to dynamically adapt to the dynamic environment. The Network-Oriented Modeling approach described in (Treur 2016; Treur 2020) and used here fulfils this requirement.

This paper proposes a mental network model for goal driven emotion regulation. This study takes distraction and rumination regulation strategies into account as both these strategies focus on the same early stage in emotion generation wherein distraction attenuates while rumination amplifies attention to the emotion inducing a stimulus (Lewis et al. 2015; Thiruchselvam et al. 2011). In the rest of the paper, Sect. 2 discusses literature on the question under investigation, Sect. 3 presents the network model and its mathematical representation. Section 4 gives scenario for the simulation and insight into the simulation results of the model. Section 5 concludes the paper.

2 Background

The occurrence of impairments in emotion regulation strategies in depression has long been an established fact (Joormann and Siemer 2014) and is attributed to dysfunctional strategies. However, recently it has been found that such impairments can also be attributed to dysfunctional emotion goals (Millgram et al. 2015). Therefore, (Tamir et al. 2019) suggest that intervention in emotion regulation should somehow focus on activation of adaptive emotion goals so that it may activate the adaptive means by emotion regulation strategies to achieve those goals (Millgram et al. 2019). Preferences for emotions depends on the goals that are intended to be achieved (Tamir et al. 2007; Tamir 2005). There can be situations where people are motivated to just increase unpleasant emotions rather than decreasing pleasant emotions (Wood et al. 2003) or maintain unpleasant emotions (Heimpel et al. 2002). These findings suggest that individuals can also be motivated for experiencing bad or unpleasant emotions if it helps in achieving some goals. Two types of goals play a role here, one refers to emotion goals and the other refers to more general goals (e.g., task-related) that are intended to be achieved, where emotion goals can be supportive for that.

According to (Tamir 2016), emotion regulation serves a specific motive and its nature and consequences are solely dependent on the motives that the emotion regulation is intended to serve. The first motive in emotion regulation should either direct or take a person away from specific goals and the second motive may specify the way in which emotion goals and their attainment are pursued. To sum it up, it can be said that "the stronger the motive, the greater the likelihood of pursuing the emotion goal that is expected to serve it" (Tamir 2016). Contrary to (Carver and Scheier 1998; Locke and Latham 1990), who are of the view that goals are deliberately activated via conscious or intentional thoughts, (Bargh et al. 2001; Shah and Kruglanski 2003) suggest that it's the perception of stimulus that, if it has some association with the goals, should alone be able to activate the goals. The perception doesn't need to be conscious (Greenwald et al. 1996; Greenwald 1992), and even if it's conscious, the person may not be aware that the perception has activated an entire array of associated memories and goal constructs (Ferguson and Bargh 2004).

According to (Suri et al. 2015), like all other behaviors, people can be motivated for emotion regulation if it has some cost effectiveness. Motives activate behavior that helps in achieving specific desired goals (Elliot and Niesta 2009), which, in case of emotions, means that motives influence or help in selection of specific emotion goals (Tamir 2016). For instance, runners amplify their anger if they feel it helps in running faster (Lane et al. 2011). People increase their anger before a confrontational task to the level that they feel will help in performing better (Tamir and Ford 2012). Similarly, people prefer to feel sadder while trying to perform better at analytical tasks (Cohen and Andrade 2004). Relations between motives, emotion goals and outcomes have been very nicely summed up in (Tamir 2016):

> 'For a motive to give rise to a specific emotion goal, people must associate the emotion with the desired outcome. People are likely to vary both in the nature and in the strength of associations they form between specific emotional states and desirable or undesirable outcomes. The stronger the associations between an emotion and the outcome, the more likely it is that people would pursue that emotion to satisfy the related motive.' Similarly, (Lane et al. 2011) elaborate it by an example as under: 'two athletes may be equally motivated to win a competition, but the emotions they pursue to satisfy this motive can differ dramatically depending on which emotion they expect would promote performance' (Tamir 2016), p. 215.

Apart from satisfaction of the motives, flexibility in mapping emotion goals also defines psychological health (Kim et al. 2015). Less flexibility in matching strategies to goals has been marked as emotional dysfunction (Millgram et al. 2019). Moreover, "what people want to feel can determine how they regulate emotions" (Millgram et al. 2019). For instance, if a person is motivated to decrease his emotional intensity, he may go for distraction and for rumination if the person is motivated to increase his emotional intensity.

As emotion regulation strategies, distraction and rumination are two attention-deployment strategies having an inverse effect on emotion when compared to each other, as distraction is considered to decrease emotion (Shafir et al. 2015) by decreasing the amount of attention directed towards the emotion inducing stimulus (Naragon-Gainey et al. 2017) while rumination is considered to increase emotions (Nolen-Hoeksema et al. 2008) by increasing attention towards the emotion inducing stimulus (Naragon-Gainey et al. 2017). Selection of one of these strategies is subjected to whether the person is motivated to increase or decrease his emotional experience; i.e. people should, more likely, turn to distraction when motivated to decrease the intensity of their emotions and rumination when motivated to increase the intensity of their emotions (Millgram et al. 2019).

3 The Mental Network Model

The proposed computational network model is inspired and based on the vast body of literature summarized above and developed using the Network-Oriented Modeling approach described in (Treur 2016; Treur 2020). Here networks of states are used that are dynamic based on temporal-causal connections between them: the state values change over time by the causal impact of a number of states on another state over time. It uses labels for network characteristics Connectivity, Aggregation and Timing as given below:

- **Connectivity.** Nodes X and Y, interpreted as states, are connected to each other with *connections* $X \rightarrow Y$ defining causal impact; each connection carries *a connection weight* $\omega_{X,Y} \in [-1, 1]$.
- **Aggregation.** For each state Y, a combination function $\mathbf{c}_{Y}(..)$ is chosen to defi*ne the aggregated* incoming causal impact from *v*arious other states
- **Timing.** Each state Y has a speed factor $\boldsymbol{\eta}_{Y}$ which shows how fast state Y changes because of the causal impact exerted on it by the other states

This Network-Oriented Modeling approach has been shown to be quite effective in modeling highly dynamic and interactive mental and social processes, which often involve dynamic and cyclic interactions of mental and social states. Also adaptive networks of different orders can be modeled; then some of the above labels for network characteristics become adaptive; see (Treur 2020). The mental network model shown in Fig. 1 was developed based on the above Network-Oriented Modeling approach. Table 1 provides a description of the states of the model. The mental network in Fig. 1 describes the process of activation as well as regulation of emotions motivated by some kind of goals. The goals refer to both emotion as well as goals (e.g., task-related) in the real world. The red connections represent negative connections. In this network model, the causal pathway from stimulus s leads to the activation of goal state for emotion goals gs_{em}, goal state for task gs_t in the real world and the motivation state ms_{motv} for achieving the emotion goals. The emotion goal then activates preparation for the suitable emotional state, i.e., anger $ps_{b.ang}$ in case of the example scenario for this model, for achieving the goals in real world gs_t. Regulation of this "perceived suitable emotional state" (i.e., anger) is further up- or down-regulated using emotion regulation strategies (rumination cs_{rmnt} and distraction cs_{dstr}, respectively) in a flexible way. Here the choice of strategies is dependent on the context. Similarly, the choice to increase or decrease the intensity of the emotional state (i.e. anger) is also dependent on the context. For instance, in case of the above mental network model, it's perceived that if anger is increased the person will be able to meet a certain deadline in his work. So, the person increases his anger by using rumination cs_{rmnt}.

On the other hand, the same emotional state (i.e., anger) is decreased using distraction cs_{dstr} when interrupted by another external stimulus; for example, a daughter srs_{ds} in

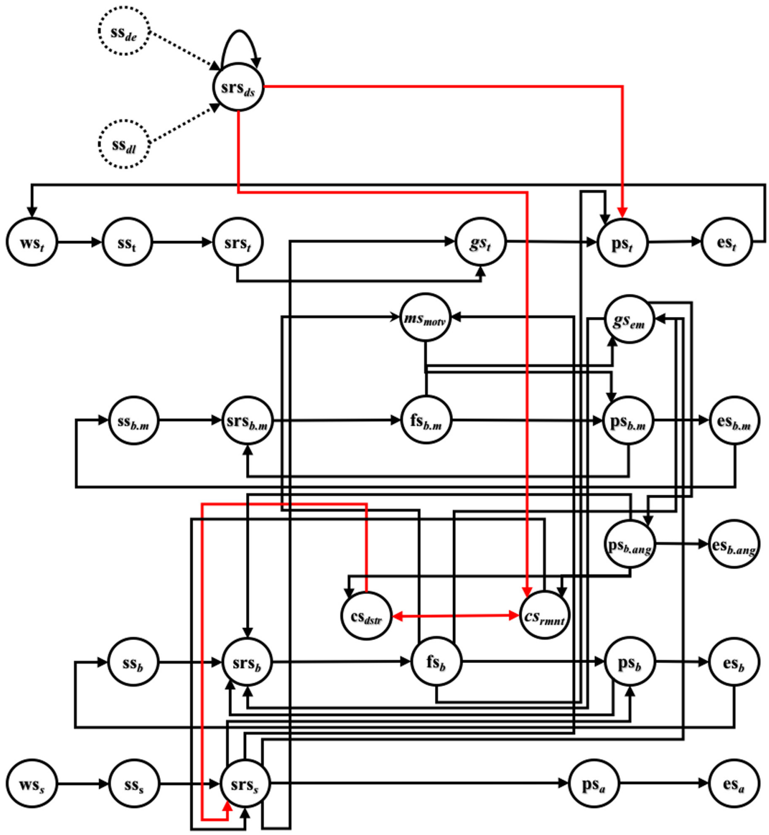

Fig. 1. Computation model for goal driven emotion regulation

case of this model. In the latter case, distraction suits the context as the person wants to deal with his daughter with love, for which he needs to decrease his anger. In contrast, in the former case, rumination is more suited to achieve the intended emotional state as it amplifies attention to the stimulus.

Transformation of the above conceptual representation of a temporal-causal network model into numerical representation takes the steps given below; these steps are automated by a dedicated software environment described in (Treur 2020), Ch. 9:

1. Every state *X,* at a given time point *t,* has a value $X(t)$ between 0 and 1.
2. The causal impact of state X on Y at time point t is computed as $\mathbf{impact}_{X,Y}(t) = \omega_{X,Y}\boldsymbol{X(t)}$ where $\omega_{X,Y}$ represents the weight of the connection $X \to Y$.
3. Impact of multiple incoming causal connections to Y from $X_1 \ldots X_k$ is aggregated as:

$$\mathbf{aggimpact}_Y(t) = \mathbf{c}_Y\left(\mathbf{impact}_{X1,Y}(t), \ldots, \mathbf{impact}_{Xk,Y}(t)\right) \tag{1}$$

$$= \mathbf{c}_{\mathrm{Y}}\left(\omega_{X1,Y}X_1(t), \ldots, \omega_{Xk,Y}X_k(t)\right) \tag{2}$$

where $\mathbf{c}_Y(\ldots)$ represents combination function of state Y.

Table 1. States and their explanation.

Name	Description	Name	Description
$ws_{(s,\ t)}$	World state for stimulus *s*, task *t*	ms_{motv}	Monitoring state for motivation *motv*
$ss_{(s,\ b,\ b.m,\ t,\ de,\ dl)}$	Sensor state for stimulus *s,* body state *b,* body state for motivation *b.m,* task *t,* daughter enters *de,* daughter leave *dl*	$es_{(a,\ b,\ b.ang,\ b.m,\ t)}$	Execution state for action *a*, body state *b*, body state for anger *b.ang*, body state for motivation *b.m,* task *t*
$srs_{(s,\ b,\ b.m,\ t,\ ds)}$	Sensory representation state for the stimulus *s,* body state *b,* motivation *b.m,* task *t,* daughter status *ds*	$ps_{(a,\ b,\ b.ang,\ b.m,\ t)}$	Preparation state for physical action *a,* body state *b*, body state for anger *b.ang*, body state for motivation *b.m,* task *t*
$fs_{(b,\ b.m)}$	Feeling state for body *b,* motivation *b.m.*	gs_{em}	Goal state for emotions *em*
$cs_{(dstr,\ rmnt)}$	Control state for distraction *dstr,* rumination *rmnt*	gs_{t}	Goal state for task *t*

4. Timing of the impact of $\mathbf{aggimpact}_Y(t)$ on Y is determined by speed factor η_Y as below:

$$Y(t + \Delta \text{t}) = Y(t) + \eta_Y \left[\mathbf{aggimpact}_Y(t) - Y(t)\right] \Delta \text{t} \tag{3}$$

$$\text{or } \ \mathbf{d}Y(\text{t}) / \mathbf{d}\text{t} = \eta_Y \left[\mathbf{aggimpact}_Y(\text{t}) - Y(\text{t})\right] \tag{4}$$

5. Thus, the difference and differential equations obtained are given as under:

$$Y(t + \Delta t) = Y(t) + \eta_Y \left[\mathbf{c}_\text{Y}\left(\omega_{X_1,Y} X_1(t), \ldots, \omega_{Xk,Y} X_k(t)\right) - Y(t)\right] \Delta t \tag{5}$$

$$\text{or } \ \mathbf{d}Y(t) / \mathbf{d}t = \eta_Y \left[\mathbf{c}_Y\left(\omega_{X_1,Y} X_1(t), \ldots, \omega_{X_k,Y} X_k(t)\right) - Y(t)\right] \tag{6}$$

4 Settings and Simulation Results for an Example Scenario

Besides giving deeper insight of the network model, this section of the paper makes this model easily reproducible. Table 2 shows all the connections' weight values of the network model. Table 3 provides the values for combination functions and speed factors of the various states. Providing these connection values along with the values provided in Table 3 to the model, will yield the results shown in Figs. 2 and 3.

In Table 3 below, the identity function **id**(V) = V, has been used for the states with only one incoming connection that do not have any value for steepness σ and threshold τ. The advanced logistic sum combination function Eq. (7) has been used for the states with more than one incoming connection. World state ws_s has an initial value 1. Similarly, srs_{ds} has initial value 0.11 for the case of $\tau = 0.2$, and 0.9 as initial value for the case of $\tau = 0.8$; this is to make the external context factor (daughter) appear or disappear in the middle of the process.

Table 2. Connection weights for getting the desired results

Connection	Weight	Connection	Weight	Connection	Weight
$\omega_{wss, sss}$	1	$\omega_{psb, esb}$	0.8	$\omega_{psb.m, srsb.m}$	0.4
$\omega_{sss, srss}$	0.5	$\omega_{esb, ssb}$	0.6	$\omega_{psb.m, esb.m}$	0.8
$\omega_{srss, psa}$	0.4	$\omega_{csdstr, srss}$	−0.45	$\omega_{esb.m, ssb.m}$	0.8
$\omega_{srss, psb}$	0.6	$\omega_{csdstr, csrmnt}$	−1	$\omega_{msmotv, psb.m}$	0.5
$\omega_{srss, msmotv}$	0.4	$\omega_{csrmnt, srss}$	0.5	$\omega_{gsem, srsb}$	0.2
$\omega_{srss, gsem}$	0.2	$\omega_{csrmnt, csdstr}$	−1	$\omega_{gsem, psb.ang}$	0.8
$\omega_{srss, gst}$	0.6	$\omega_{psb.ang, srsb}$	0.1	$\omega_{wst, sst}$	0.6
$\omega_{psa, esa}$	0.4	$\omega_{psb.ang, csdstr}$	1	$\omega_{sst, srst}$	0.7
$\omega_{ssb, srsb}$	0.1	$\omega_{psb.ang, csrmnt}$	1	$\omega_{srst, gst}$	0.2
$\omega_{srss, fsb}$	0.8	$\omega_{psb.ang, esb.ang}$	0.8	$\omega_{gst, pst}$	0.1
$\omega_{fsb, psb}$	0.2	$\omega_{ssb.m, srsb.m}$	0.4	$\omega_{pst, est}$	0.8
$\omega_{fsb, msmotv}$	0.25	$\omega_{srsb.m, fsb.m}$	0.6	$\omega_{est, wst}$	1
$\omega_{fsb, gsem}$	0.2	$\omega_{fsb.m, psb.m}$	0.2	$\omega_{srsds, csrmnt}$	−1
$\omega_{fsb, pst}$	0.6	$\omega_{fsb.m, gsem}$	0.4	$\omega_{srsds, pst}$	−0.8
$\omega_{psb, srsb}$	0.2			$\omega_{srsds, srsds}$	1

The advanced logistic sum combination function is defined by:

$$\mathbf{alogistic}_{\sigma,\tau}(V_1, \ldots, V_k) = \left[\left(1/\left(1+e^{-\sigma(V1+\ldots+Vk-\tau)}\right)\right) - 1/\left(1+e^{\sigma\tau}\right)\right]\left(1+e^{-\sigma\tau}\right) \tag{7}$$

4.1 Example Scenario Used for Simulation

The following example scenario, based on findings from literature in Psychology, has been simulated using the proposed model:

Table 3. Values of steepness, threshold and speed factor of each state

State	σ	τ	η	State	σ	τ	η
ws_s	0	0	0	$ss_{b.m}$	8	0.5	1
ss_s	0	0	1	$srs_{b.m}$	8	0.3	1
srs_s	8	0.4	0.2	$fs_{b.m}$	8	0.3	1
ps_a	0	0	0.5	$ps_{b.m}$	8	0.3	1
es_a	0	0	0.5	$es_{b.m}$	8	0.3	1
ss_b	8	0.3	1	ms_{motv}	8	0.3	0.8
srs_b	8	0.3	1	gs_{em}	8	0.3	0.8
fs_b	8	0.3	1	ws_t	8	0.3	0.5
ps_b	8	0.3	1	ss_t	8	0.3	0.5
es_b	8	0.3	1	srs_t	8	0.3	0.5
cs_{dstr}	8	0.4	0.4	gs_t	8	0.3	0.5
cs_{rmnt}	8	0.2	0.5	ps_t	8	0.3	0.5
$ps_{b.ang}$	10	0.4	1	es_t	8	0.3	0.5
$es_{b.ang}$	10	0.6	0.8	srs_{ds}	18	0.2, 0.8	0.02

While working from home, Mr. Fahad gets angry at his colleagues' progress, as he is the only one yet to complete the assigned task. He ruminates his anger to stay focused and complete the task but his daughter interrupts him in between. So, he distracts his attention away from his colleagues' progress to deal with her with love and gets free from the assigned task which he wants to pursue while being angry as it increases his efficiency.

Figure 2 illustrates a situation where the person achieves one emotion goal (i.e., anger) but then his emotion goal changes as a result of an external factor (interrupting daughter). In the figure it can be seen that the daughter srs_{ds} is not present yet but the stimulus srs_s has already happened and the person's motivation state ms_{motv}, goal state for emotion gs_{em} and goal state for task gs_t in the external world already were activated. Here the person's emotion goal is to get angry, modeled by emotional response $ps_{b.ang}$. The emotion goal activates the strategy which helps in achieving the emotional state that the person is motivated to achieve (i.e. anger) represented by response state $ps_{b.ang}$ so that he can achieve his goal in the external world es_t. So, it activates the control state for increasing rumination cs_{rmnt} which increases attention towards the emotion inducing stimulus srs_s (progress of his colleagues in their assigned tasks). Rumination helps the person to get angry and hence stay more focused to working on his task. After a certain time, it can be seen that srs_{ds} gets activated which means that the daughter of the person enters the room which changes his emotion goal because he wants to deal with her with love. So, the emotion goal, now, is to reduce anger $ps_{b.ang}$. As per findings from Psychology, the emotion goal activates the means to achieve the corresponding

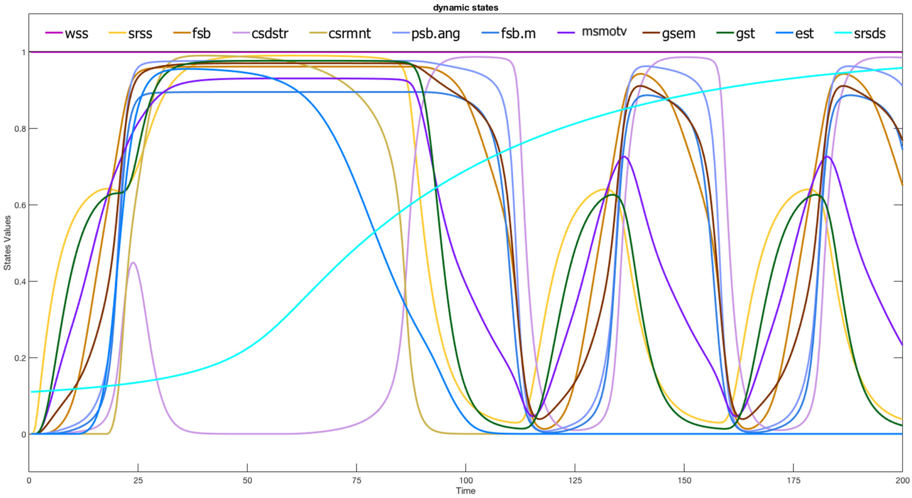

Fig. 2. Contextual switching from rumination to distraction

emotional state, i.e., it activates the control state for distraction cs_{dstr}. Activation of distraction reduces the intensity of srs_s and the associated states like ms_{motv}, gs_t but just like a more realistic situation, the intensity of the stimulus still keeps fluctuating and takes the person's attention. That's why the pattern will keep repeating itself until his daughter leaves and he gets busy in the task or he has completed the task.

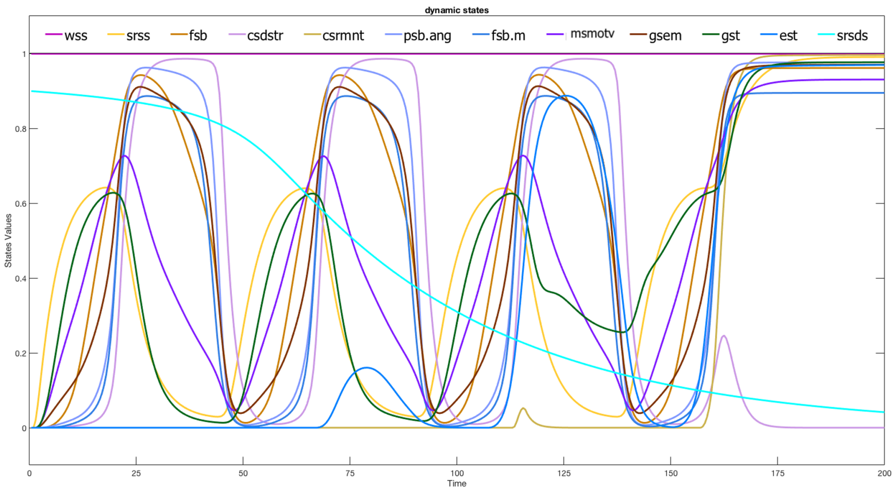

Fig. 3. Contextual switching from distraction to rumination

Figure 3 shows a situation where a person is delaying an intended emotional state by distracting his attention away from the primary stimulus srs_s to a secondary stimulus srs_{ds}. Here, the person's emotion goal is to keep his anger reduced as he wants to deal with his daughter with love. At the same time, he also has the primary stimulus in his mind which he thinks can be coped with by achieving a different emotional state, i.e. anger. To deal with the secondary stimulus srs_{ds}, the current emotion goal activates the control state for distraction cs_{dstr} to move his attention away from the primary stimulus srs_s. the fluctuation of the curves indicates the intensity of the srs_s and the person's eagerness to complete the task. After a while, as his daughter leaves (srs_{ds} decreases), the emotion goal changes from reducing anger to increasing anger $ps_{b.ang}$. The new emotion goal now activates a different strategy for achieving the new emotional state, and, therefore, switches from distraction cs_{dstr} to rumination cs_{rmnt}. It can be observed in the figure that as soon as srs_{ds} decreases enough, all the states automatically start getting higher to some extent, even before the activation of the cs_{rmnt}. This phenomenon is exactly in line with the findings from Psychology which state that the stimulus itself (unintentionally) activates an entire array of processes. Those processes also include activation of the means to achieve emotion goals, i.e. some emotion regulation strategy. That phenomenon can be observed here.

5 Conclusion

This paper presents a computational mental network model for goal driven emotion regulation. It is based on the findings from social sciences and psychology. This network model, with the help of simulation results, in a graphical way explains how some (negative) emotional state can prove adaptive in certain situations and help in achieving certain goals in the real world. It, on one hand explains the adaptivity of negative emotional states (dependent on the context); on the other hand, this model also demonstrates the contextual switching between emotional states. Bringing theoretical knowledge from social sciences and Psychology into computational science, this model shows how goals (emotional as well as other goals) activate the means to achieve those goals. This mental network model has been made possible by the dynamicity and wide applicability of network-oriented modeling approach (Treur 2016); see (Treur 2020) for a more updated and extended version of the approach.

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