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Research Article

The Role of Affective Updating in the Cognitive Reappraisal Strategy of Emotion Regulation

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Abstract

Recent studies show that executive functions play an essential role in different strategies of emotion regulation (ER). The present study explored updating of information in working memory as a possible cognitive basis of cognitive reappraisal. Updating of affective information was examined, in particular, because cognitive tasks using affective material might be more relevant for the research relating to executive functions and ER. Sixty-three participants with mean age of 21.31 (*SD* = 4.03; 61% female and 39% male) took part in the experiment. To measure affective updating, an affective version of the *n*-back task had been developed using emotional faces as stimuli. Cognitive reappraisal was measured with Gross Emotion Regulation Questionnaire. A positive relationship was obtained between affective updating and cognitive reappraisal. It was suggested that ER should be more strongly related to affective rather than non-affective updating because ER requires the ability to control the processing of the emotional information particularly.

Keywords: Emotion regulation, cognitive reappraisal, executive functions, updating, suppression.

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Executive functions are cognitive processes involved in the control and regulation of the cognitive processes at the lower level (Alvarez & Emory, 2006). They are the foundation of goal-directed behavior, planning, and a host of other types of behavior related to cognitive control. Recent research and theorizing (see Schmeichel & Tang, 2015) suggest that executive functioning may serve as the cognitive basis for emotion regulation (ER). In general, ER involves the processes and strategies that are adopted to control the experience and expression of emotions (Gross, 1998). The inability to regulate emotion is associated with undesirable outcomes including poor psychological well-being and emotional and behavioral disorders. Since ER is a form of goal-directed behavior, individual differences in executive functioning can explain different degrees of ER efficacy (Schmeichel & Tang, 2015).

There is no consensus on the precise list of executive functions. However, among many executive functions described in the literature (e.g., Diamond, 2013), updating of working memory representations is regarded as one of the most important for a wide array of tasks. Updating is defined as the process of monitoring incoming information for the relevance to the current task and replacing no longer applicable items held in working memory by newer and more relevant ones (Miyake et al., 2000). Research shows that deficits in updating are related to depression (Harvey et al., 2004; Matsuo et al., 2007) and can be precursors for psychological maladjustment and other impairments in thought and actions (Levens & Gotlib, 2010). Supposedly, the ability to maintain relevant affective information in working memory and to replace it by other, probably neutral information when necessary can be very advantageous for ER. On the other hand, it has been suggested that a deficit in updating results in impairment of ER and emotional maladjustment (Joormann et al., 2007).

To better understand the role of updating in ER, it is instructive to consider separately different strategies of ER because they are very diverse and engage different cognitive processes. One prominent theory developed to explain ER and its strategies is the process model by Gross (1998). The process model distinguishes five kinds of ER strategies, namely

situation selection, situation modification, attentional deployment, cognitive change, and response modulation (Gross, 2015). Two of them are believed to have cognitive elements; attentional deployment and cognitive change (Suri et al., 2013). Attentional deployment is a group of processes that direct attention in a way that allows a person to change an emotional response to a situation. The typical strategy of attentional deployment is attentional distraction. Cognitive change is focused on the interpretation rather than perception of the situation altering the way the situation is understood and appraised. The typical strategy of cognitive change is cognitive reappraisal that allows a person to see a new meaning of the situation which results in a change in emotional responding. For instance, in order to regulate the anxiety associated with an impending exam results, a student can reinterprete the results as showing only a fraction of their general competence, with the ultimate goal of controlling the anxiety.

Updating seems to be especially important for cognitive reappraisal. Indeed, to produce less negative or even positive appraisals of negative events, a person must effectively change certain emotional contents in working memory. In particular, it is crucial to be able to replace negative with neutral or more positive information – a task that is often difficult to implement for depressed individuals (Levens & Gotlib, 2010).

A handful of studies (e.g., Levens & Gotlib, 2015; Xiu et al., 2016) examined the relationship between updating and ER. One of the established procedures to measure updating is the *n*-back task (Kirchner, 1958; Owen et al., 2005) in which participants monitor the identity of serially presented stimuli and indicate if the current stimulus is the same or different from the one presented *n* steps earlier. Thus, the *n*-back task includes both the monitoring of working memory content and replacing it when necessary.

Schmeichel et al. (2008) examined the role of working memory in ER using various working memory tasks. They found that the higher performance of the verbal and spatial *n*-back tasks predicted more successful cognitive reappraisal while watching scary emotional videos. Sperduti et al. (2017) explored the contribution of various executive functions – updating, working memory capacity, shifting, and inhibition – to spontaneous emotional downregulation based on cognitive reappraisal. They found that only updating (measured with the *n*-back task with letters as stimuli) predicted effective downregulation of intense negative emotions. Xiu et al. (2016) trained their participants' updating ability using the running working memory task and also administered the *n*-back task with letters. ER was measured with the task in

which participants had to reappraise the stimuli presented to them. They also found that updating was positively related with the ability to downregulate negative emotions.

Pe et al. (2013a; 2013b; 2015) in a series of studies used an affective version of the *n*-back task with emotional words as stimuli. Two of these studies engaged the cognitive reappraisal strategy of ER. The first study (Pe et al., 2013a) did not search for direct relationships between updating and cognitive reappraisal but showed that the efficacy of cognitive reappraisal in down-regulating negative emotions is moderated by affective updating ability. The second study (Pe et al., 2015) showed directly that affective updating predicted effective cognitive reappraisal of negative emotions during the performance of two different ER tasks.

Another updating measure, the keep track task, was used by Hendricks & Buchanan (2016). The task involves presenting participants with a set of categories (e.g., colors, animals, faces) in each trial on a computer screen, and later asking them to recollect the last item in each category (Miyake et al., 2000; Yntema, 1963). Higher performance on the keep track task predicted the reduction of negative affect when participants regulated their emotions performing cognitive reappraisal and expressive suppression tasks.

Other working memory tasks were also used in the attempt to find cognitive predictors of reappraisal. It has been shown that cognitive reappraisal is related to the operation span task (McRae et al., 2012; Schmeichel et al., 2008) and non-affective and affective versions of the reading span task (Coifman et al., 2019). The operation span task involves solving arithmetic equations while remembering a list of unrelated words. In the reading span task, participants are presented with unrelated sentences for them to read aloud and asking them to remember the last word in each sentence (Daneman & Carpenter, 1980; Turner & Engel, 1989). Sometimes these tasks are erroneously interpreted as updating tasks (see Coifman et al., 2019; Schmeichel & Tang, 2015). However, strictly speaking, they measure memory capacity rather than updating.

The use of different experimental paradigms and cognitive tasks makes the results of several studies not perfectly comparable. Only a few studies addressed directly the issue of the role of updating in cognitive reappraisal. Our study aimed at obtaining new evidence on the relationships between updating and the cognitive reappraisal strategy of ER. We used the 2-back task for measuring updating. This task seems to be one of the most valid operationalizations of updating, because to perform it, a person must be able to monitor the stimulus representations in working memory and replace them following task requirements (Schmiedek et al., 2014). The load factor of 2 was selected for the *n*-back task because it

makes the task difficult enough to have a reasonable degree of accuracy rate variability (see Gajewski et al., 2018).

The important new feature of the present study is that affective updating was explored unlike most other studies that focused only on non-affective updating. For this reason, an affective version of the 2-back task was developed, that is, emotional facial expressions rather than neutral material were taken as stimuli. In most studies reviewed above, updating was measured with cognitive tasks using non-affective material. Only Pe et al. (2013a; 2013b; 2015) used an affective version with emotional words as stimuli. There is a debate about the possible impact of information's affective salience on executive functions. Recent studies (including a meta-analysis) explored this issue comparing affective and neutral versions of working memory tasks with the *n*-back task (Mohammed, 2019; Schweizer et al., 2019). No substantial difference has been found between affective and neutral tasks at the behavioral level (Mohammed, 2019; Schweizer et al., 2019), however, these two types of tasks recruited partially different brain networks (Schweizer et al., 2019). Importantly, individuals with mental health problems perform affective versions of working memory tasks poorer compared to neutral versions. This evidence suggests that cognitive tasks using affective material can be more relevant for the research relating executive functions to ER. Some studies (e.g., Pe et al., 2013a; 2013b; 2015) provide additional circumstantial evidence for this claim. For instance, Pe et al. (2013a; 2013b;) investigating the role of updating in affect balance and depression showed that those participants who were better at updating positive information reported higher life satisfaction and a more positive mood.

In the present study, ER was measured with Gross Emotion Regulation Questionnaire (Gross & John, 2003). This questionnaire measures not only the cognitive reappraisal strategy but also the expressive suppression strategy of ER. The suppression strategy was included in the analysis, but did not advance any specific hypothesis about it. Suppression was not expected to be related to updating, at least when it concerns the self-reported suppression of emotional expression.

H 1: It was hypothesized that affective updating would be positively related to the cognitive reappraisal strategy of emotion regulation.

Method

Participants

To determine the sample size, a power analysis was conducted taking into account the results of the previous studies most similar to ours (Schmeichel et al., 2008; Sperduti et al., 2017). The reported correlation coefficients between updating and cognitive reappraisal ranged from .35 to .43; this demands that the sample size should be from 32 to 49 in order to achieve the statistical power of .80. The sample for the present study consisted of 63 Russian speaking participants based in Moscow, Russia[1]. Four were excluded for their inability to complete the experimental task, reducing the final sample to 59 participants. Their ages ranged from 17 to 34 years; the mean age was 21.31 (*SD* = 4.03). Participants were largely undergraduate students (61% female and 39% male). Others were recruited from a research-based website that announced the search for individuals to participate in experiments.

Materials

Affective 2-back task

To measure updating of affective information, an affective version of the 2-back task was developed. Pictures from the EU-Emotion Stimulus Set (O'Reilly et al., 2012; O'Reilly et al., 2016) were used as stimuli. This stimulus set is made up of photographs of actors ranging from children to adults of both sexes displaying various emotions and mental states. Six pictures were selected from the excitement and happiness categories and another six pictures were selected from the anger and disgust categories. Thus, six positive and six negative facial expressions posed by different actors were selected.

Each picture was displayed on the screen for two seconds followed by an intertrial interval of two seconds. The participant was expected to press either the letter "P" if the current picture was of the same valence with the one presented two steps back, or the letter "Q" if it was different.[2] The pressed key and the response time (RT) were recorded for each trial. The task included 41 stimuli; responses to 39 of them were analyzed. Twenty stimuli were positive faces and 21 stimuli were negative faces. The task design is demonstrated in Figure 1. The task was carried out using the PsychoPy software (Peirce et al., 2019).

[1] The study was approved by the Institutional Review Board of the National Research University Higher School of Economics.
[2] For instance, if the present displayed picture is anger and the picture displayed two steps back is disgust, the letter "P" is pressed because they are both negative emotions. Examples are shown in Figure 1.

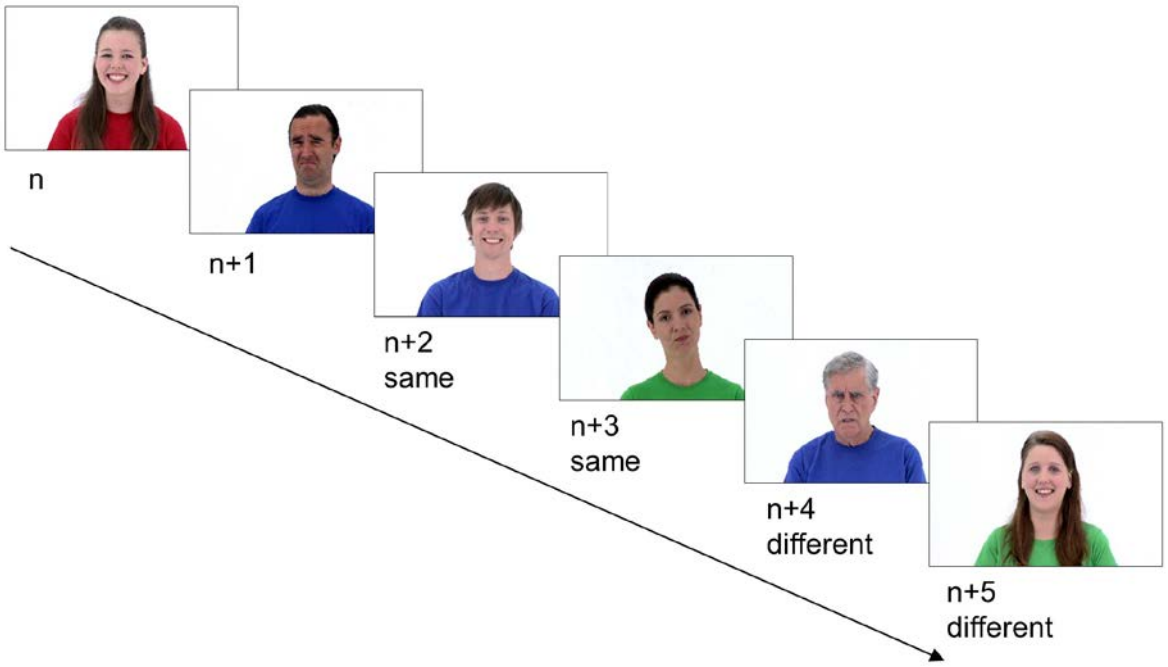

Figure 1. The design of the affective 2-back task used in the study with stimuli from the EU-Emotion Stimulus Set. All images were obtained from the database of the EU-Emotion stimulus set.

Emotion Regulation Measure

The Russian adaptation of the Emotion Regulation Questionnaire (ERQ: Gross & John, 2003; Pankratova & Kornienko, 2017) was used to measure ER strategies. The questionnaire is made up of two scales, Cognitive Reappraisal and Expressive Suppression. The Cognitive Reappraisal scale consists of six items (e.g., "I control my emotions by changing the way I think about the situation I'm in"), whereas the Expressive Suppression scale contains four items (e.g., "I control my emotions by not expressing them"). Cronbach's alphas of the scales of the Russian version are .79 (6 items) and .75 (4 items), respectively.

Procedure

The participants were informed that the purpose of the experiment was an investigation of the processing of emotional information and signed an informed consent. Next, there was a training session for the affective 2-back task. Twenty positive and negative facial expressions not used in the main session were presented to the participants. The percentage of correct answers was displayed on the screen at the end of the training session. The participant was allowed to proceed to the main session after obtaining 60% or above in accuracy. If the participant failed in the first training task, the session was repeated up to three times. This

was followed by the main affective 2-back task. Afterwards, the participants were presented with a few tasks related to a different research project. The experiment was completed by filling out the ERQ. The participants were subsequently debriefed on the actual aim of the experiment.

Results

Mean accuracy rates and mean RTs of correct responses to the trials of the affective 2-back task were used as indices of affective updating. To test the hypothesis about the positive relationship between affective updating and cognitive reappraisal, Pearson correlations were calculated between accuracy rates and RTs and the two scales of the ERQ (Table 1)[3].

Table 1.

Correlations between the ERQ scales and performance of the affective 2-back task (N=59).

	Mean (SD)	ERQ: Reappraisal	ERQ: Suppression	Mean accuracy
1. ERQ: Reappraisal	28.83 (7.66)	-		
2. ERQ: Suppression	14.02 (4.42)	.072	-	
3. Mean accuracy	.81 (.12)	.288*	-.003	-
4. Mean RT	1.17 (.23)	-.003	-.038	-.285*

Note: * $p < .05$

The results showed that accuracy of affective updating correlated positively with the cognitive reappraisal strategy $r(57) = .288$, $p = .027$. This meant that the higher the accuracy rates of affective updating, the higher the cognitive reappraisal strategy of ER. Furthermore, mean RTs were also compared with cognitive reappraisal strategy of ER. The results showed that mean RTs were not related to cognitive reappraisal of ER ($r(57) = -.003$, $p = .982$).

Although there was no prediction on any relationship between suppression strategy and updating, we however tested their relationships. The results showed that neither mean accuracy ($r(57) = -.003$, $p = .982$) nor mean RT ($r(57) = -.038$, $p = .078$) were related to suppression strategy of emotion regulation.

Discussion

The present study aimed at examining the relationship between updating of affective information in working memory and ER. Specifically, it was hypothesized that updating of

[3] All indices met the normality distribution criteria, hence the decision to use the parametric test.

affective information would be positively related to cognitive reappraisal strategy of ER. As predicted, there was a positive correlation between accuracy rate of updating and the cognitive reappraisal strategy of ER. Although this was not the case with RT of updating and the cognitive reappraisal strategy. One can suggest that RT was a less valid operationalization of updating in the present study because the time allotted for the response was limited for each trial. This produced a regular and rapid rhythm of a participant's performance and made the index of mean RT insensitive to the individual differences in updating. This idea is indirectly supported by the low correlation found between the mean accuracy rates and mean RTs (as shown in Table 1). As expected, the suppression strategy was not related to affective updating.

The obtained positive relationship between affective updating and cognitive reappraisal supports the findings of some previous studies (Hendricks & Buchanan, 2016; Pe et al., 2015; Schmeichel et al., 2008; Sperduti et al., 2017; Xiu et al., 2016). The peculiarity of the present study was the focus on affective updating. Other studies (except for Pe et al., 2015) used non-affective stimuli in updating tasks. Also, for the first time, emotional facial expressions were used instead of emotional words as stimuli.

Does it matter if affective or non-affective updating is examined when we are searching for the relationships between updating and ER? As mentioned in the introduction, Schweizer with colleagues' meta-analysis (Schweizer et al., 2019) showed that the performance of affective working memory tasks was lower compared to neutral working memory tasks in participants with mental health problems. Also, Pe et al. (2013a; 2013b) found positive correlations between updating of positive stimuli, on the one hand, and life satisfaction and positive mood, on the other hand. These results suggest that updating of affective information might be of particular importance for ER. McRae et al. (2012) found no differences in the relationships between cognitive reappraisal and affective and non-affective versions of the OSPAN task. However, this task measures working memory capacity rather than updating.

It is suggested that ER should be more strongly related to affective updating because ER requires the ability to control the processing of the emotional information particularly. To test this suggestion, it is necessary to compare both types of updating directly. From the literature search conducted, it appears that little or no study of this kind has been published so far. The comparison of the relationships of neutral and affective updating tasks with cognitive reappraisal strategy of ER in one experiment should be implemented in future studies.

Limitations and further implications

There are some limitations to be discussed. First, the study was correlational and hence could not really show the causal directions of the relationships between updating and cognitive reappraisal. Is it the ability to update affective information that leads to better cognitive reappraisal or vice versa? Second, the study recruited largely undergraduate students belonging to a restricted age group. Hence, the present findings cannot be generalized to the larger society and other age groups. More studies are needed with different groups of people to understand the extent to which the present findings are generalizable.

Conclusion

In conclusion, the present study makes important contributions towards the understanding of the relationship between updating and ER. The present finding provides more clarity on the relationship between updating and cognitive reappraisal by showing that affective updating is more relevant to cognitive reappraisal compared to non-affective updating. This implies that interventions that focus on helping individuals to elaborate the cognitive reappraisal strategy of ER should aim to improve their ability to update information including affective material in their working memory.

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Competing Interests

The authors have declared that no competing interests exist.

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