A Comparison of Emotion Regulation Strategies' Effectiveness under Cognitive Fatigue

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ABSTRACT

Previous studies have shown differences in effectiveness among emotion regulation strategies under cognitive fatigue. However, a few studies attempted to compare multiple strategies together. The objective of this research is to compare the effectiveness of cognitive reappraisal, distraction, and affect labeling under cognitive fatigue using self-report negative emotions and skin conductance. In the 2 (fatigue vs. non-fatigue) × 3 (emotion regulation strategies) within-subject design, 46 participants were randomly assigned into conditions using an incomplete block design method. Participants were instructed to use emotion regulation strategies while watching emotion-eliciting pictures. Self-report emotion and skin conductance responses were measured to compare the effectiveness of the strategies. Results have shown that reappraisal was more effective in regulating negative emotions than did distraction and affect labeling in both fatigue and non-fatigue conditions. While reappraisal was a robust method of regulating emotion, the other two less-demanding strategies show some promising results. The present study provided a consistent conclusion with previous works which showed that reappraisal worked better than distraction and affect labeling. However, no difference in emotional responses was found when comparing the cognitive fatigue condition.

KEYWORDS: Cognitive Fatigue, Emotion Regulation, International Affective Pictures System (IAPs), Skin Conductance

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INTRODUCTION

An ability to cope with unpleasant emotions is essential for a healthy life (Gross & Thompson, 2007). Failure to regulate emotions is implicated in a number of psychological disorders, such as depression and anxiety (Gross & John, 2003). At the same time, emotion regulation is implemented to help people with disorders such as borderline personality disorder and other related personality disorders. Emotion regulation primarily refers to the process of cognitively controlling our emotions, the attention we give to emotions, and the way we interpret and experience emotions (Gross, 1998). Various emotion regulation strategies have been explored and identified in the last few decades, and they were found to differ in their effectiveness in regulating emotions (Gross & John, 2003; Gross & Thompson, 2007). One possible explanation for differential effectiveness and success among emotion regulation strategies is that a) some strategies may require distinct amount of cognitive resource from others and b) individuals differ in their capacity to cognitively employ each emotion regulation process. Research has shown that decreased cognitive resources weakened emotion regulation's effectiveness and that emotion regulation undermined performance on cognitive tasks (e.g., working memory span; Schmeichel, 2007). These findings support the view that cognitive tasks and emotion regulation rely on the same limited and depletable resources (Grillon et al., 2015). These findings demonstrated the impact of cognitive resources on emotion regulation and vice versa.

Among the three mainly studied emotion regulation strategies, *cognitive reappraisal* probably received the most attention among researchers. The strategy, which was first studied by Gross (1998), refers to a way in which individuals change how they think about a situation before emotions take place. Research has shown that reappraisal was a promising strategy when dealing with negative emotions (Gross, 1998; Ray et al., 2005).

Similar to reappraisal, a substantial body of research suggests that *attentional distraction* may be an effective way to manage negative emotions (Thiruchselvam et al., 2011; Tracey et al., 2002). Attentional distraction involves shifting focuses in order to deploy attention away from emotional stimuli. Distraction has been found to decrease negative emotions (Webb et al., 2012), particularly when associated with problem-focused coping. Even though distraction has been shown to alleviate negative emotions (Tracey et al., 2002), evidence suggested that reappraisal was more effective than distraction in some situation such as when individuals down-regulated the emotional experience (McRae et al., 2010).

Another newly introduced emotion regulation strategies is *affect labeling*, which involves solely verbally labeling an emotional content of an external stimulus (i.e., fearful or angry face; Lieberman et al., 2007). At first glance, putting feeling into words may not seem to be an effective way to cope with emotions. However, investigations have shown the effectiveness of this strategy across various contexts (Burklund et al., 2014; Lieberman et al., 2007). In addition, neuroimaging studies also found that reappraisal, distraction, and affect labeling resulted in the same manner, that is, they all reduced amygdala activation (Giorgetta et al., 2012; Grecucci et al., 2013; Hariri et al., 2000; Moyal et al., 2014). These studies suggest that the three emotion regulation strategies are effective in decreasing negative emotions.

In this paper, we aimed to uncover the effect of cognitive fatigue on a wider range of emotion regulation strategies, namely, cognitive reappraisal, attentional distraction, and affect labeling. Based on the Process Model of Emotion Regulation (Gross, 1998), we hypothesized that different emotion regulation strategies would be different in their effectiveness of decreasing negative emotion. Moreover, the three strategies would be differently influenced by cognitive fatigue due to the distinct cognitive demands of each strategy. We also used both the self-report negative emotions and skin conductance responses to emotion stimuli to assess negative emotions.

Materials and Methods

Study Design

An incomplete randomized block design for a 3 (strategies) by 2 (fatigue) within-subject conditions was employed in order to reduce the length of the experimental session and kept the participants engaged. In this design, one participant was randomly assigned into 4 of 6 conditions, resulting 30 observations from 45 participants for the entire design.

Participants

Forty-nine individuals (M_{age} = 22.4; 41 female) were recruited through classes and social networks and received a compensation of 200 Baht (≈$6) for their participation. Data from 3 individuals were excluded from the analysis due to non-responses of skin conductance that occurred during the experiment. Thus, final result was 46 participants.

Materials

Cognitive Fatigue Tasks. The task consisted of a series of mental calculations including additions, subtractions, multiplications, and division which consists of 1–3 digit numbers and three levels of calculation, for instance, (345 - 127) * 6. In the non-fatigue condition, the calculation consisted of 1 – 2 digits number and two levels of calculation (e.g., 12 + 7). These tasks lasted for 10 minutes.

Emotion Regulation Tasks. These tasks required individuals to regulate their emotions that were elicited from the IAPS pictures. The instructions were derived from a meta-analysis of Webb et al. (2012) for reappraisal (e.g., "change your emotions by reinterpret what you see in the pictures") and distraction (e.g., think about something positive that is unrelated to the pictures in order to distract yourself") and from Lieberman et al. (2011) for affect labeling (e.g., "try to name the emotion you are experiencing"). Before each emotion regulation task, participants were trained for each regulation strategy by watching instructional video clips at the beginning of each emotion regulation condition. After the training session, participants were presented with three emotion regulation tasks in a random order. Each emotion regulation condition consisted of five IAPS pictures and lasted 30 seconds per picture. At the end of each picture, participants completed a self-report negative emotions rating.

Emotion Stimuli. Seventy pictures from the International Affective Picture System (IAPS; Lang et al., 2008) were rated by 33 individuals in a pilot study using the Self-Assessment Manikin (Bradley & Lang, 1994), a non-verbal assessment technique in pictorial form that directly measures the valence, arousal, and dominance associated with a person's emotional response to stimuli. The SAM comprises single-item scales that measure valence of the response (7 = *positive* to 1 = *negative*), perceived arousal (7 = *high* to 1 = *low* levels), and perceptions of dominance/control (1 = *low* to 7 = *high*). In this study, neutral pictures were categorized by valence rating between 3.5 to 5 and the arousal rating between 1 to 3; negative pictures had valence between 1 to 3.5 and arousal between 4.3 to 7. Thirty negative pictures[1] were selected as experimental stimuli. These pictures consisted of mixed negative emotions including fear, disgust, and sadness. Five negative and five neutral pictures were selected as baseline-controls.

[1] **Number of IAPs pictures:** 3001, 1271, 1525, 1301, 1202, 9187, 1270, 1050, 6231, 8370, 9163, 1114, 2345.1, 1051, 1022, 1932, 9940, 1040, 1052, 1026, 3005.1, 1033, 1280, 1310, 8192, 1274, 1726, 8186, 8192, 1811, 1111, 1300, 1930, 1019, 1201, 7000, 7004, 7009, 7025, 7090

Measures

Physiological Activity. Skin Conductance Response (SCR) was utilized as the physiological measure of negative emotional arousal. In this study, the SCR was recorded with ProComp infiniti: Electrodermal Activity device (EDA; Thought Technology Inc.). Skin conductance signals were transmitted via two electrodes attached to the ring and middle fingers of the non-dominant hand. Participants were informed that the experiment involved measuring skin conductance 24 hours before the experiment, and they were asked to follow skin conductance checklists (i.e., no alcohol for 24 hours and no coffee for 3 hours before the study).

Self-report Negative Emotions. A rating scale question read "how intense was your feeling?", was used to assess the participant's negative emotional experience, 1 = *did not feel any negative emotion at all* to 7 = *strongly felt negative emotions*. The item was presented following each IAPS picture.

Self-reported Difficulty of Tasks. The difficulty of tasks was assessed by a rating scale question "how difficult was the task?" ranging from 1 = *the task was not difficult at all* to 7 = *the task was strongly difficult*, following cognitive fatigue task.

Procedures

After giving informed consent and being screened for exclusion criteria, SCR electrode were placed on the distal phalanges of the first and middle finger of a participant's non-dominant hand. Next, participants completed two baseline-control emotion regulation tasks: one with 5 neutral pictures and one with 5 negative pictures, respectively. An incomplete block design was, then, used to deliver a 2 (fatigue condition) × 3 (emotion regulation strategies) within-within-subject conditions as described above. Each participant would complete 4 out of 6 conditions. The assigned conditions were arranged into the fatigue condition set or the non-fatigue condition set. Participants either completed all strategies in the fatigue condition set first then the non-fatigue condition set, or vice versa. Between the two set, participants were given a 10-minute rest. In the fatigue condition set, participants began with the cognitively demanding mental calculation for 10 minutes, then, rated the difficulty of the task. After that, they completed each of the assigned emotion regulation strategy condition in succession. Within each strategy condition, they were presented with an instructional video pertaining to the assigned strategy. Participants were told that they should not close their eyes or look away from the pictures. Subsequently, in each regulation strategy condition, the participants regulated their emotional responses to five randomly-presented IAPS pictures using the strategy described on the screen. The emotion intensity rating was collected at the end of each picture. The non-fatigue condition set followed the same patterns, albeit employing the less cognitively demanding calculation task. The experimental stimuli were delivered via E-Prime 3.0 (Psychology Software Tools). At the end of the experiment, participants were asked manipulation check questions and were received their compensation and thanked for the participation.

Ethical considerations

This study was approved by Chulalongkorn University Institutional Review Board No. 169.1/62.

Data Analysis

All statistical analyses were performed using the open-source language R 3.6 (R development Core Team, 2019). Linear mixed-effect modeling performed by lme4 package(Bates et al., 2014), was used in order to test the effect of each emotion regulation strategies. Linear mixed-effect models contains fixed effect (explanatory variables) and random effects (variance components).

Skin conductance response data preprocessing

The skin conductance data were imported and analyzed with Ledalab.GUI (Benedek & Kaernbach, 2010), a toolbox for skin conductance data analysis in MATLAB (MATLAB, 2018). The data were, then, down-sampled from 256Hz to 32Hz. A continuous decomposition analysis (CDA) was used to extract the SCR Phasic information of each emotion regulation task. In this study, sum of amplitudes of significant skin conductance response within each emotion regulation task was used as a dependent variable with minimum amplitude threshold of 0.01 uS. Then, Tukey's Ladder of Powers transformation was applied to transform sum of amplitudes data to approach a normal distribution.

Results

Comparisons of Emotion Regulation Strategies against Control Group

Linear mixed-effect models were designed to predict each of the outcome variables: self-report negative emotions and sum of SCR phasic amplitude. The first models' results from a random intercept showed that the self-report negative emotions in all six experimental conditions were significantly lower than the negative baseline-control. (M_{exp} = 2.19 – 3.34 vs. $M_{neg\text{-}base}$ =

4.14). While the sum of amplitudes, only reappraisal in non-fatigue condition (*M* = 1.50, *SD* = 0.33) showed the result lower than the negative baseline control (*M* = 1.53, *SD* = 0.32). See **Table 1** for mean of each condition and **Table 2** for the model's coefficients.

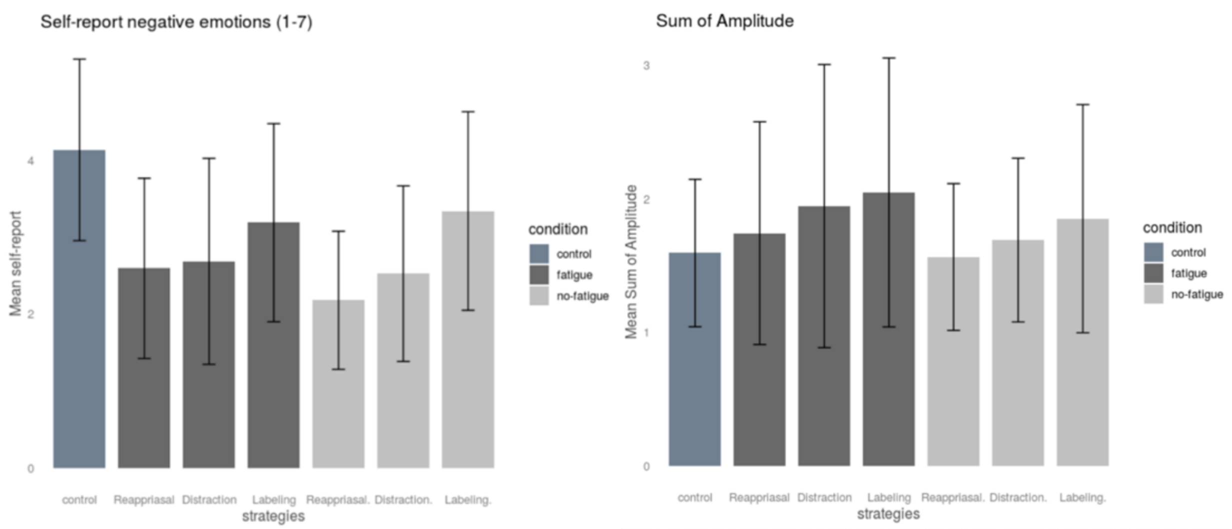

Figure 1: a) Shows Self-Report Negative Emotions for Each Emotion Regulation Strategy,
b) Shows Standardized Sum of Amplitudes for Each Emotion Regulation Strategy Measured by Skin Conductance Device

Comparisons of Emotion Regulation Strategies and Fatigue Conditions

Self-reported Negative Emotions. The overall of this model explained 58.8% of the negative emotions variance, while the fixed factors explained 11.6% of the variance. The results revealed that the difference between the fatigue and non-fatigue conditions was not significant (b = - 0.36, p = .106). For the main effect, affect labeling is significantly higher than reappraisal (b = 0.70, $p < 0.001$) while distraction is not significantly different from reappraisal (b = 0.22, p = 0.304). Furthermore, the interaction between regulation strategies and cognitive fatigue was not significant. The result of likelihood ratio of the simple main effect model and the interaction effect showed no significantly different (χ^2 (2) = 3.70, p = 0.16).

Sum of Amplitudes. The overall model predicting sum of amplitudes explained 5.65% of the variance, and explained 5.65% by fixed factors. Consistent with the self-report emotions, the effect of cognitive fatigue was not significant for the sum of amplitudes (b = -0.01, p = 0.915). Similarly, affect labeling showed significant different to reappraisal (b = 0.09, $p < 0.05$) while distraction showed no significant difference (b = 0.03, p = 0.395). There was no significant interaction between the fixed factors. The result of likelihood ratio of the simple main effect model and the interaction effect model showed no significantly different (χ^2 (2) = 0.50, p = 0.78). See the full results in **Table 3**.

Table 1. Means and Standard Deviations for the Two Dependent Measures for all Conditions.

Condition	**Strategies**	**Self-Report** (n = 46)	**Sum of Amplitude** (n = 45)
Control	Control	4.14 ± 0.18	1.53 ± 0.32
Fatigue	Reappraisal	2.60 ± 1.17	1.54 ± 0.38
Fatigue	Distraction	2.69 ±1.34	1.72 ± 0.56
Fatigue	Labeling	3.19 ± 1.29	1.92 ± 0.70
Non-fatigue	Reappraisal	2.19 ± 0.90	1.50 ± 0.33
Non-fatigue	Distraction	2.53 ± 1.14	1.64 ± 0.46
Non-fatigue	Labeling	3.34 ± 1.29	1.77 ± 0.60

Note. The control condition was the negative-baseline condition

Table 2. Random Intercept Model for Seven Conditions Nested in Participants

Predictor		**Self-report**			**Sum of Amplitude**		
condition	strategy	*estimates*	*SE*	*p*	*estimates*	*SE*	*p*
(Intercept)		4.14	0.17	< 0.001	-0.70	0.02	< 0.001
Fatigue	Reappraisal	-1.61	0.21	< 0.001	-0.01	0.04	0.914
Fatigue	Distraction	-1.45	0.20	< 0.001	0.04	0.04	0.235
Fatigue	Labeling	-0.88	0.20	< 0.001	0.13	0.04	0.006
Non-fatigue	Reappraisal	-2.00	0.21	< 0.001	-0.001	0.04	0.727
Non-fatigue	Distraction	-1.60	0.21	< 0.001	0.05	0.04	0.388
Non-fatigue	Labeling	-0.72	0.21	0.001	0.06	0.04	0.086
Random Effects		$\sigma^2 = 0.76$			$\sigma^2 = 0.02$		
		τ_{00} id = 0.63			τ_{00} id = 0.00		
		Conditional $R^2 = 0.588$			Conditional $R^2 = 0.055$		
		Marginal $R^2 = 0.247$			Marginal $R^2 = 0.055$		

Note. The baseline-control was coded as a reference condition

Table 3. Random Intercept Model for Fatigue Conditions and Strategies Nested in Participants

Predictor	**Self-report**			**Sum of Amplitude**		
	estimates	*SE*	*p*-value	*estimates*	*SE*	*p*-value
(Intercept)	2.50	0.20	< 0.001	-0.72	0.03	< 0.001
Non-fatigue	-0.36	0.31	0.106	-0.01	0.04	0.914
Distraction	0.22	0.21	0.304	0.03	0.04	0.401
Labeling	0.70	0.22	0.001	0.09	0.04	0.009
Distraction * Non-fatigue	0.29	0.31	0.523	0.01	0.56	0.845
Labeling * Non-fatigue	0.59	0.31	0.059	-0.03	0.06	0.637
Random Effects	$\sigma^2 = 0.65$			$\sigma^2 = 0.02$		
	$\tau_{00\ id} = 0.75$			$\tau_{00\ id} = 0.00$		
	Conditional $R^2 = 0.588$			Conditional $R^2 = 0.057$		
	Marginal $R^2 = 0.116$			Marginal $R^2 = 0.057$		

Note. Fatigue condition and reappraisal were coded as reference conditions

Discussion

In contrast to Grillon et al. (2015), we did not find the effectiveness of emotion regulation strategies depended on cognitive fatigue. Actually, we did not even find the main effect of cognitive fatigue. While the simplest explanation would be that the fatigue manipulation failed to generate the desired effect, participants still indicated that they perceived the fatigue condition to be more difficult than the non-fatigue condition. It is possible that although the mental calculation, a common paradigm to induce cognitive fatigue, might be cognitive demanding for the participants, they were not depleted of their cognitive resource to the point that would hinder their regulation performance. When completing the unfamiliar emotion regulation tasks, the participant might still be able to tap into their cognitive reserves to compensate for fatigue from the mental calculation. The other possibility could be that participants were cognitively fatigued in both condition and the 10-minute break were not enough for a recovery. In the latter explanation, it could mean that the effectiveness of each strategy was less dependent on the available cognitive resources as we originally thought; and that the reappraisal strategy was robust even in the face of cognitive constraints.

The current study also investigated the effectiveness of three emotion regulation strategies: cognitive reappraisal, attentional distraction, and affect labeling. We found that, regardless of the cognitive fatigue conditions, all three strategies were more effective in reducing self- negative emotion than the baseline-control, where the participants were not explicitly told to use any regulation strategy. These findings were in line with previous studies which compared the effectiveness of reappraisal and distraction (Bettis et al., 2018; McRae et al., 2008; Strauss et al., 2016), as well as, reappraisal and affect labeling (Lieberman et al., 2011) against a control condition. Moreover, among the three strategies, cognitive reappraisal was shown to be consistently more effective than distraction and affect labeling in the self-report measure. However, in the skin conductance measure, reappraisal and distraction did not significantly differ and, at the same time, both were more effective than affect labeling. It is possible that while both reappraisal and distraction strategies were similarly successful at diminishing negative emotions at the physiological level, the participants might not be fully aware of such effect. By contrast, affect labeling seemed to be the least effective among the three strategies, especially in the self-report emotion. Lieberman et al. (2011) suggest that individuals may not believe that labeling their emotions is useful for decreasing negative feelings. Such bias could play a role in self-report measures. Nonetheless, the physiological measure showed a similar trend to the self-report measure, suggesting that affect labelling was not on a par with cognitive reappraisal in terms of reducing negative emotions.

Furthermore, the sum of SCR phasic amplitudes was found to be unexpectedly low in the baseline-control tasks. Several possibilities exist. Stronger physiological responses in emotion regulation conditions than those in the baseline-control could be explained with the carry-over effect as the baseline-control always appeared at the beginning of the experiment. Schwartz and Andrasik (2017) suggested that temporal factor might cause participants to become physically fatigue. Such effect could interfere with physiological measurement over time. Sze et al. (2010) also found that high level of bodily emotional awareness is associated with subjective emotional experience. Therefore, when participants were requested to perform such strategies, their emotional awareness might arise. As such, their physical reactions also emerge simultaneously. However, this explanation could not account for the fact that self-report emotion in the baseline-control was higher than the experimental conditions. The implicit-explicit distinction seems more probable in this case. Commonly, explicit emotion regulation involves an explicit goals and controlled change process, while implicit emotion regulation involves more autonomic change processes with implicit goals (for a review, see Braunstein et al., 2017). These two dual-processes paradigms could explain a degree to which participants' self-reports were higher than the sum of SCR amplitudes in the control-baseline. Typically, individuals had their own way to regulate emotion if they were not instructed to do any specific regulations. Research has suggested that even without explicit instruction, people reported that they used emotion regulation fairly regularly on a daily basis (Gyurak et al., 2011). This so called "habitual emotion regulation" can be initiated quickly and effortlessly as an implicit response to emotional stimuli. Nonetheless, this implicit process might occur automatically outside participants' awareness. As a result, they might not show a decrease in self-report emotion, though they physiological responses had already been regulated.

The limitation of this present study was that, the majority of samples of this study were university students who differ in some ways from the population in the same age range (18 - 30 years old). The difference in an ability to access one's own thought and background knowledge could impact how one would redirect thoughts and construct a reasonable ones to deal with negative emotions. Future studies could include a wider range of participants.

CONCLUSIONS

Emotion regulation is a fundamental ability to adapt individual's behavior to different situations. Different emotion regulation strategies have been explored in many domains such as clinical, psychology mental health, neuroscience, etc. The present study provided a consistent conclusion with previous works which showed that reappraisal worked better than distraction and affect labeling. On the other hand, we could not demonstrate any difference in emotional responses when comparing the cognitive fatigue conditions, suggesting that the three strategies may very sensitive to the decrease cognitive resources.

Acknowledgement

We would like to acknowledge the participants who completed the study, as well as, the members of our team in the physiological laboratory. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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