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Why expressive suppression does not pay? Cognitive costs of negative emotion suppression: The mediating role of subjective tense-arousal

Abstract: *The aim of this paper was to contribute to a broader understanding of the cognitive consequences of expressive suppression. Specifically, we examined whether the deteriorating effect of expressive suppression on cognitive functioning is caused by tense arousal enhanced by suppression. Two experiments were performed in order to test this prediction. In both studies we tested the effect of expressive suppression on working memory, as measured with a backwards digit-span task (Study 1, N = 43) and anagram problem-solving task (Study 2, N = 60). In addition, in Study 2 we tested whether expressive suppression degrades memory of the events that emerged during the period of expressive suppression. Both studies were conducted in a similar design: Participants watched a film clip which evoked negative emotions (i.e. disgust in Study 1 and a combination of sadness and anxiety in Study 2) under the instruction to suppress those negative emotions or (in the control condition) to simply watch the film. The results of these experiments lead to three conclusions. First, the results reveal that expressive suppression degrades memory of the events that emerged during the period of expressive suppression and leads to poorer performance on working memory tasks, as measured with a backwards digit-span task and anagram problem-solving task. Second, the results indicate that expressive suppression leads to a significant increase in subjective tense arousal. Third, the results support our prediction that expressive suppression decreases cognitive performance through its effects on subjective tense arousal. The results of the Study 1 show that tense arousal activated during expressive suppression of disgust fully mediates the negative effect of suppression on working memory as measured with a backwards digit-span task. The results of Study 2 reveal that subjective tense arousal elicited while suppressing sadness and anxiety mediates both the effect of suppression on working memory – as measured with the anagram task – and memory of the events that occurred during the period of suppression.*

Key words: *expressive suppression, subjective tense arousal, memory, working memory*

Introduction

Emotions are a crucial part of human functioning and adjustment. Most current theories of emotion share the functionalist approach and emphasize that over the course of evolution human emotions have arisen as a system of adaptation, whose main function is to organize and coordinate activities that are relevant to an individual's needs and goals (Cosmides & Tooby, 2000). Although emotional responses usually contribute to adaptive behavior and are well suited for successful coping with the environmental challenges, there are situations when emotions lead to dysfunctional behavior, and in such instances, the ability to regulate emotions is a hallmark of successful human functioning on both intra- and inter-personal levels. Emotion regulation refers to those processes by which "individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (Gross, 1998a, p. 275). Emotion regulation can take place during different phases of emotion process (Frijda, 1986; Szczygieł, 2014). We may try to change our evaluation of the situation, or to avoid the emotional situation itself, and we may also try to modify the course and expression of our emotional experiences (Gross, 1998b; Gross & Thompson, 2007; Parkinson & Totterdell, 1999).

Research shows that one common way that individuals regulate emotions is through expressive suppression (ES). ES involves conscious and effortful inhibition of the overt

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expression of emotion while an individual is emotionally aroused. It is a form of response-focused emotion regulation, i.e., it occurs relatively late in the emotion process, potentially after affective experience has already been generated and after response tendencies have been initiated (Gross, 1998a, 1998b). An example of ES is trying to look composed while feeling shattered inside. Most people believe that ES is the most effective way to control emotions (Gross, Richards & John, 2006; Loewenstein, 2007). Experimental studies have demonstrated the efficiency of suppression in reducing expressive behavior, i.e., participants asked to suppress their expressive behavior show fewer behavioral signs of emotion than control participants (e.g., Bonanno, Papa, Lalande, Westphal, & Coifman, 2004; Gross & Levenson, 1993, 1997). However, a great deal of research demonstrates that concealing feelings has its price.

First, experimental data shows that suppressing negative emotion-expressive behavior does not decrease self-reported experience of negative emotions, such as anger, sadness, disgust and embarrassment (Gross & Levenson, 1997; Harris, 2001; Richards & Gross, 1999; Richards & Gross, 2000). Individual differences studies, using the suppression scale of the Emotion Regulation Questionnaire (ERQ, Gross & John, 2003), are consistent with experimental research and show that individuals who frequently engage in ES in daily life report increased levels of negative emotions (Gross & John, 2003; John & Gross, 2007).

Second, suppression leads to increased physiological arousal. For example, Richards and Gross (1999) have demonstrated that suppression of negative emotions induces changes in the cardiovascular system and leads to an increase in some of the indicators of physiological stress (e.g., constriction of blood vessels and electrical conductivity of the skin). Similarly, Gross and Levenson (1993) have observed that suppressing disgust decreased heart rate, but increased sympathetic activation of the cardiovascular and electrodermal physiological systems. Gross and Levenson (1997) have found that suppressing sadness led to increased sympathetic activation of the cardiovascular system, as indexed by changes in finger temperature and finger pulse amplitude. Similarly, Harris (2001) found that suppressing visible signs of embarrassment leads to enhanced blood pressure responses. It is noteworthy that in the above mentioned studies suppression decreased visible signs of emotions but had no effect on reports of experienced emotions.

To sum up, suppressing emotional expression of negative emotions allows us to give the impression of being calm, cool and collected on the outside. But inside we experience just as much negative emotion and even more physiological arousal as we do when we freely express our feelings. However, the side effects of ES are not limited to the affective realm.

Cognitive consequences of suppressing emotional expression

Over the past 15 years, a considerable amount of research has been conducted to examine whether ES affects cognitive functioning. The results unequivocally demonstrate that ES degrades memory of the events that transpired during the period of ES (e.g., Richards, 2004; Richards & Gross, 1999). For example, Bonanno and colleagues (2004) have demonstrated that people who concealed emotional facial expressions in response to pleasant and unpleasant slides remembered the slides worse than participants in the control condition. Similarly, suppressing both facial and vocal cues of emotion while talking about important relationship conflicts with a romantic partner led to reduced memory of what was said during a conflict conversation (Richards, Butler, & Gross, 2003). Also, as compared with no-regulation participants, individuals who were asked to conceal facial expressions while watching others argue were found to remember the argument worse than no-regulation participants (Richards & Gross, 2000, Study 1). What is important, worse memory is associated with both experimentally induced and spontaneously occurring ES (Richards & Gross, 2006).

We shall now turn our attention to research on working memory (WM), where the effects of ES on performance have been extensively investigated. WM is an umbrella term for the ability to maintain and process information in the mind over short periods of time – around a few seconds (Baddeley, 2002). It is used in mental tasks requiring understanding, language comprehension, verbal fluency, reasoning, complex problem-solving, as well as more complex and demanding tasks, such as planning and decision-making (Cowan, 2010; D'Esposito, 2007). WM is an important feature of our cognitive functioning, because cognitive tasks can be accomplished only with sufficient ability to hold information as it is processed (Cowan, 2010). There is ample empirical evidence to suggest that ES leads to poorer performance on WM tasks. For example, Baumeister, Bratslavsky, Muraven and Tice (1998, Study 3) observed that participants who were instructed to suppress all internal reactions to an unpleasant movie and all external signs of their feelings performed worse on a subsequent anagram problem-solving task (i.e., unscrambling letters to form new words). The results of a study conducted by Inzlicht and Gutsell (2007) showed that suppressing emotional facial expressions while watching an unpleasant movie led to poor performance on the color-naming Stroop task, which is considered a general measure of processing speed and cognitive flexibility (Uttl & Graf, 1997). Szczygieł, Buczny and Bazińska (2012) observed that participants instructed to engage in ES showed poorer performance relative to controls on a subsequently administered measure of emotional information processing (i.e., matching facial expressions). Furthermore, Schmeichel, Vohs, & Baumeister (2003, Study 2) demonstrated that ES while watching an upsetting emotional video impairs logical reasoning, cognitive extrapolation and complex reading comprehension but has no impact on general knowledge.

In summary, the above-mentioned data demonstrates the deleterious effects of ES on human cognitive functioning. However, one question that still remains unanswered: what are the mechanisms underlying the effects of suppression on cognitive performance?

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Cognitive functioning and physiological arousal

Richards and Gross (1999) have proposed a possible explanation of the deleterious effects of ES on cognitive functioning. They put together evidence demonstrating that emotional suppression leads to an increase in physiological arousal (Gross, 1999; Gross & Levenson, 1993, 1997) and research showing that physiological arousal interferes with performance in both sensorimotor and cognitive tasks (Christianson, 1992; Neiss, 1988; Noteboom, Fleshner, & Enoka, 2001; Revelle & Loftus, 1992). Consequently, they came to the conclusion that ES may decrease cognitive performance through its effects on physiological arousal. Thus, the potential mechanism of suppression associated with poorer cognitive performance could be that arousal enhanced by suppressing emotional responses leads to disturbances in information processing. This could explain why suppressors exhibit (1) poorer memory of the events that happened during the suppression period and (2) impairment of performance on subsequent cognitive tasks. The rationale for such a reasoning could be the cue-utilization theory of Easterbrook (1959), which predicts that arousal affects cognitive performance through its effects on information processing (see also Mather & Sutherland, 2011). According to Easterbrook's theory, heightened arousal leads to attention narrowing, defined as a decrease in the range of details (cues) from the stimulus and its environment to which the organism is sensitive. Therefore, attention is focused primarily on the arousing details of the stimulus, so that information central to the source of the emotional arousal are encoded while peripheral details are not.

The empirical studies evaluating the effect of arousal on cognitive memory performance brought mixed results. Richards and Gross (1999) observed that physiological arousal (assessed by means of blood pressure and finger temperature) was heightened by ES, however, mediational analyses showed that psychological arousal and memory were not affected. On the other hand, Lacey and Lacey (1974) demonstrated that increases in heart rate and blood pressure deteriorated sensory reception, thereby exacerbating the event encoding processes that shape memory. However, to make the whole picture more confusing, Schönfeld, Ackermann and Schwabe (2014) demonstrated that autonomic arousal, expressed as a change in blood pressure, was positively correlated with memory retrieval under stress but unrelated to retrieval 25 min post stress. In contrast, the cortisol response to the stressor was negatively correlated with retrieval performance 25 min after stress but unrelated to retrieval under stress.

It is puzzling, therefore, why there are such discrepancies in studies on the effects of physiological arousal on cognitive functioning. Hanoch and Vitouch in their review article (2004) attributed such inconsistency to a tendency to conceptualize emotional arousal as a unidimensional construct. They questioned the general usage of the term 'emotional arousal' as one that represents a whole range of emotional arousal states and pointed out that "psychologists tend to use the arousal construct as if it represents a wide range of physiological manifestations. In fact, one can view the arousal construct as a meta-construct, since it serves as a rubric for a wide range of physiological changes. In other words, any physiological change (e.g., increase in blood pressure, heart rate, hormonal surge or brain activity) fits into the rubric of arousal. It is not clear, therefore, whether the employment of the term 'arousal' in one experiment necessarily has any correspondence or similarities to its usage in any other experiment" (Hanoch & Vitouch, 2004, p. 43).

Hanoch and Vitouch (2004) refer to empirical evidence which indicates that certain emotional states have specific patterns of autonomic activation (Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, & Friesen, 1990). For example, Zajonc and McIntosh (1992, p. 72) provided the juxtaposition of differences in physiological changes (i.e., heart rate, finger temperature, skin conductance and muscle activity) among the six basic emotions (happiness, fear, sadness, anger, disgust and surprise) that were found in several studies. Cacioppo, Berntson, Larsen, Poehlmann, and Ito (2000) conducted a meta-analysis of all published studies comparing the effects of at least two distinct emotions on at least two autonomic measures. The results showed that fear, anger, and sadness were associated with greater heart rate acceleration than disgust, but disgust was associated with a greater increase in skin conductance response than happiness, and fear was associated with lower diastolic blood pressure than anger. On the other hand, it is known that various emotions are matched to various adaptive requirements. Some emotions, such as anger, entail performing complex activities, while other emotions, such as sadness, trigger more complex adaptive programs (for discussion, see Matthews, Zeidner, & Roberts 2002).

The results also show that the relationship between a discrete emotion and physiological arousal is moderated by the technique of inducing emotions, that is, different emotion inductions seem to cause different autonomic patterns (for discussion, see Larsen, Berntson, Poehlmann, Ito & Cacioppo, 2008). Hanoch and Vitouch (2004) conclude that emotional arousal can elicit both deleterious and beneficial effects on cognitive functioning, depending on what the experimenter decides to measure, that is, what kind of physiological activity is taken into account (e.g., skin conductance, heart rate, blood pressure).

There is another issue that needs consideration. Nęcka (2000) notes that while physiological measurement is sometimes regarded as more objective and therefore more reliable than psychological variables, in particular, self-report data, the interpretation of physiological variables raises serious problems because of the low correlation between various indicators of physiological arousal (Lacey, 1967). Revelle and Loftus (1992, p. 122) emphasize that "the independence of the separate physiological measures is not evidence against the validity of the arousal construct. Rather it suggests that separate control processes have developed to modulate energy availability, and that it is this sum of available energy that people report as arousal."

Given the limited applicability of physiological indices to psychological research (see discussion in

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Nęcka, 2000) some researchers suggest that an alternative to physiological measures of arousal is to evaluate the subjective feelings of arousal by self report (Revelle & Loftus, 1992).

One of the most influential contemporary theories of arousal was proposed by Thayer, who has explicated two separate dimensions (i.e., orthogonal factors) describing a current arousal state: energetic arousal (ranging from feeling sleepy to feeling awake) and tense arousal (ranging from feeling calm to feeling nervous; Thayer, 1996). Tense arousal and negative affect covary strongly as do energetic arousal and positive affect (Thayer, 1989). Empirical data confirms the distinctiveness of these 2 dimensions of psychological arousal (Schimmack & Reisenzein, 2002). Importantly, energetic and tense arousals differ not only with respect to subjective experience but are also associated with different patterns of brain activity (Thayer, 1989; see also Schimmack & Reisenzein, 2002). Moreover, Thayer (1989) has demonstrated that when measures are taken within subjects, self reports of arousal correlate more highly with each of the separate physiological measures (i.e., heart rate, finger blood volume, and skin conductance) than the measures do with each other (see also Fila-Jankowska & Szczygieł, 2004). This suggest that self-report may be a better indicator of generalized arousal than single physiological indices (Thayer 1989; for a similar line of argument, see Böhringer, Schwabe, & Schächinger, 2010).

Studies have shown that arousal can either facilitate or impair performance of cognitive tasks, depending on which dimension of subjective arousal (energetic vs. tense) was tested. Whereas energetic arousal can improve cognitive performance, tense arousal has been shown to impair performance in cognitive tasks (e.g., Matthews & Davies, 2001; Matthews & Westerman 1994; Riediger, Wrzus, Klipker, Müller, Schmiedek, & Wagner, 2014).

Thus, the following question arises: Is it possible that the adverse effects of ES on cognitive functioning are due to subjective tense arousal enhanced by suppression? This is the question that inspired the current study.

The present study

The purpose of the present article is threefold: (a) to extend the findings concerning the cognitive consequences of emotion suppression, (b) to assess whether suppression increases subjective tense arousal, and (c) to examine whether subjective tense arousal mediates the impact of ES on cognitive functioning.

The effects of ES were examined in 2 studies. In both studies we tested the effect of ES on WM, as measured with a backwards digit-span task (Study 1) and anagram problem-solving task (Study 2). In addition, in Study 2 we tested whether ES degrades memory of the events that emerged during the period of ES. Both studies were conducted in a similar design: Participants watched a film clip which evoked negative emotions (i.e. disgust in Study 1 and a combination of fear, sadness, and anxiety in Study 2) under the instruction to suppress those negative emotions or (in the control condition) to simply watch the film.

Study 1

The aim of the study was to examine how emotion suppression would affect WM as measured with a backwards digit-span task.

Method

Participants

A total of 43 students of Gdansk University of Technology (Faculty of Civil and Environmental Engineering) volunteered to participate in this study. 3 female participants were excluded from the sample because they either did not wish to view the film or because they reported being unable to employ a suppression strategy. The final sample was comprised of 40 students (23 female), between the age of 19 and 25 (M = 22.80; SD = 1.66).

Materials

Emotion induction

To induce negative emotion, we selected a disgust-eliciting film [i.e., Amputation (1’ 02’’)] from a set of standardized film stimuli (Rottenberg, Ray, & Gross, 2007). This stimulus has been used in previous emotion regulation research (Gross, 1998b; Szczygieł et al., 2012).

Subjective tense arousal

We used the Polish adaptation of the UWIST Mood Adjective Checklist (UMACL) (Goryńska, 2005; Matthews, Jones, & Chamberlain, 1990) to assess participants’ tense arousal. The UMACL is a 29-item questionnaire which provides state measures of energetic arousal, tone arousal and hedonic tone. It consists of affect-adjectives and participants were asked to rate the applicability of each adjective to “their present mood”. Respondents were required to complete the questionnaire quickly to describe how they feel at that moment, and not how they usually feel; because of this the UMACL is sensitive to even momentary shifts in mood, making it ideal for measuring responses to specific situations or interventions. The response scale had four points: “definitely”, “slightly”, “slightly not”, and “definitely not”. Scoring is from 4 to 1. In this study we used only the tense arousal scale (9 items).

Cognitive performance

We used a backwards digit-span task as our assay of WM. The test was derived from the Wechsler Adult Intelligence Scale-Revised (Wechsler, 198; the Polish version: Brzeziński, Gaul, Hornowska, Jaworowska, Machowski, & Zakrzewska, 2004).

Participants heard digit sequences and were required to repeat them in a backwards order. Sequences were three to nine digits in length and were presented in an increasing length. Correct sequences were scored the same independently of sequence length, with a maximum score of 14 (seven digit lengths times two repetitions of each length). The backwards digit-span task depends on directed-attention abilities because participants must move items in and out of their attentional focus (Cowan, 2001), which is a major component of short-term memory (Jonides, Lewis, Nee, Lustig, Berman, & Moore, 2008).

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Procedure

The experiment was administered individually. Participants were randomly assigned to conditions: control (9 female and 11 male) and suppression (8 female and 12 male). After signing an informed consent form, participants were asked to assess their (pre-film) mood (i.e., tense mood) with the UMACL. Subsequently they were seated at a 60 cm viewing distance from a laptop screen and read instructions on film viewing. The instructions were based on previously established procedures (see Gross, 1998). Participants in the suppression group were instructed to inhibit their expressive behaviors and those from the control group were told to simply watch the film. Immediately after viewing the film, participants completed the UMACL again (post-film) and performed the backwards digit-span task. In this study the average internal consistency reliability (Cronbach's alpha) for pre-film and post-film subjective tense arousal were .84 and .88 respectively.

Results

Preliminary results

Kolmogorov–Smirnov tests revealed that all variables tested were normally distributed. Descriptive statistics (M and SD) for all measures are reported in Table 1. Results showed that participants experienced significantly higher post- than pre-film tense arousal and this effect was observed both in the control [$t(19) = 2.82$, $p < .05$, Cohen's $d = .63$] and suppression condition [$t(19) = 6.30$, $p < .001$, Cohen's $d = 1.41$]. Thus, participants in both conditions felt greater tension in the post-film measurement compared to the pre-film measurement. Subsequently, to obtain an additional measure, i.e., an increase in tense arousal, we calculated the change in tense arousal. As an indicator of change in tense arousal we used the difference score between the means for the post- and pre-film tense arousal (see Table 1). The results showed that an increase in tense arousal was significantly higher in the suppression condition $t(38)= 2,89$, $p < .01$, Cohen's $d = .88$]. As expected, the suppressors performed a backwards digit-span task significantly poorer than the controls: $t(38) = 2.69$, $p < .05$, Cohen's $d = .79$. We also examined the relationship between scoring on a backwards digit-span task and the tense arousal measure. Results showed that scoring on a backwards digit-span task correlated negatively with post-film tense arousal ($r = –.67$, $p < .001$) and change in tense arousal ($r = –.53$, $p < .001$). Pre-film tense arousal and performance on a backwards digit-span task were not correlated. There were no significant gender differences in the performance of cognitive task and mood dimensions, therefore gender was excluded from the analysis.

Main results

We tested whether participants' changes in subjective tense arousal mediated the effect of the experimental condition on cognitive performance.

Increase in tense arousal as a mediator of the effect of suppression on a backwards digit-span task

Following Baron and Kenny (1986; see also Figure 1), we first tested whether the experimental condition, contrast coded as $c = 0$ for the control condition and $c = 1$ for the suppression condition, was a significant predictor of cognitive performance as measured with a backwards digit-span task. As expected, this was the case, $\beta = –.40$, $p < .05$. In the second step, we used the experimental condition variable to predict participants' increase in tense arousal. This path was significant as well, $\beta = .43$, $p < .01$. Finally, we simultaneously entered the experimental condition variable and increase in tense arousal into a multiple regression predicting cognitive performance. We found that increase in tense arousal was a significant predictor of cognitive performance, $\beta = –.44$, $p < 0.01$, whereas experimental condition dropped to the mediated value $\beta = –.21$, $p = .16$, and this drop was significant as evidenced by a Sobel test, $z = 2.01$, $p < .05$. This suggests that cognitive performance as measured with a backwards digit-span task was entirely mediated by increase in tense arousal.

Table 1. Means and standard deviations of arousal measures and the performance of the backwards digit-span task for each experimental condition

Measures	Control		Suppression	
	M	SD	M	SD
Pre-film tense arousal	17.70	4.16	17.20	4.03
Post-film tense arousal	20.20	4.64	23.60	5.11
Change in tense arousal (increase)	2.50	3.97	6.40	4.55
Cognitive performance (a backwards digit-span task)	6.95	1.88	5.45	1.64

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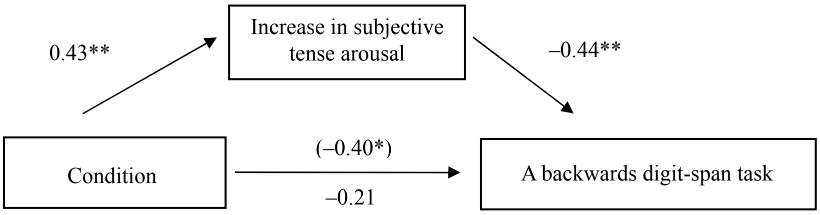
Figure 1. Increase in tense arousal as a mediator of the effect of experimental condition (contrast coded) on cognitive performance as measured with a backwards digit-span task. Values represent standardized regression coefficients. The regression coefficient in parentheses refers to the direct (unmediated) effect of experimental condition when not controlling for increase in tense arousal



* p < .05, ** p < .01

Study 2

Experiment 2 was designed to examine how emotion suppression would affect cognitive performance as measured with an anagrams task and memory of the film content task.

Method

Participants

A total of 60 students of University of Gdansk participated in this study (30 female), between the age of 19 and 27 (*M* = 23.28; *SD* = 1.49).

Materials

Emotion induction

To induce negative emotions we used a few short scenes from the motion picture *21 Grams*, directed by Alejandro González Iñárritu (2003), were used. The clip tells the story of a woman who loses her husband and two daughters in a car accident. The first short 3 scenes serve as the introduction to the main part of the film. The first scene of the clip shows a father with his two young daughters in a snack bar, laughing and joking together (19"). The second scene shows a mother making a cake with the same daughters. They are laughing and having fun (29"). Next the clip shows the mother in a support group, praising her husband for being supportive of her (27"). The fourth and the longest scene shows the mother at home alone. She receives a phone call and it is clear that something is wrong (2' 42"). Lastly, the woman drives to the hospital, where the doctor gently breaks the news that her husband is brain-dead and her two daughters have died. The woman is devastated, she is crying and shouting. In the final scene, the woman is hugged by her father and sister (1' 30"). Scenes were combined into a short movie clip (total time of the clip: 5' 36'').

Prior to the experiment, we conducted a pilot study to assess emotions elicited by the clip. A total of 12 students (8 female, 4 male) were asked to assess emotions induced by the clip. After viewing the clip, participants were given a list of 14 words describing emotions: amusement, anger, anxiety, contempt, disgust, fear, guilt, happiness, joy, love, pride, sadness, shame, surprise. The emotions' names were taken from the Post Film Questionnaire used in research conducted by Rottenberg and colleagues (2007). Participants were asked to rate each emotion using a 9-point Likert-type scale, ranging from 0 (not at all/none) to 8 (extremely/a great deal), adapted from Rottenberg and colleagues (2007). Participants declared that the film elicited the following emotions: anxiety (*M* = 6.92; *SD* = 1.24), sadness (*M* = 6.83; *SD* = 1.40), and fear (*M* = 5.48; *SD* = 1.73). Other emotions have not reached M>1. Thus, the results of the pilot study demonstrated that the movie clip successfully induced negative emotions (i.e., a combination of fear, sadness, and anxiety).

Subjective tense arousal

Subjective tense arousal was measured with the UMACL (see Study 1).

Cognitive performance

Memory of the events that occurred during the suppression period

Participants completed a memory questionnaire to assess their memory of events that took place in the movie clip. The questionnaire consists of 16 open-ended questions, e.g., "What did the doctors remove from the husband's brain?', "Who at the end of the film hugged a woman?". Participants wrote their answers in the empty space beneath each question. Responses on the memory questionnaire were scored according to the correct responses, which were subsequently changed to percentages. Therefore the results of the questionnaire ranged from 0 to 16 (i.e., from 0 to 100%).

Working memory as assessed by the anagram problem-solving task

A set of anagrams was established during the pilot study, the aim of which was to determine the number of letters in tasks and the average time needed to solve problems. We did not want to make the task too difficult, so we used anagrams with several possible answers. Participants were given a test containing 30 anagrams. All anagrams were presented on paper. The anagrams were five-letter meaningless words and participants were given

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4 min to complete all the anagram tasks. Participants were provided with pen-and-paper to assist them in the task, and could complete the anagrams in any order they wished. Anagrams had from one to three correct answers, however participants were asked to provide just one answer for each anagram. The average internal consistency reliability for the anagram problem-solving task was .75.

Procedure

The experiment was administered individually. Participants were randomly assigned to the control (15 female and 15 male) and suppression (15 female and 15 male) conditions. After signing an informed consent form, participants were asked to assess their (pre-film) mood (i.e., tense arousal) with the UMACL. Subsequently they were seated at a 60 cm viewing distance from a laptop screen and read instructions on film viewing. Participants in the suppression group were instructed to inhibit their expressive behaviors and those in the control group were told to simply watch the film. Immediately after viewing the film, participants completed the UMACL again (post-film) and performed the anagrams task. Subsequently participants completed an unexpected memory questionnaire to test their explicit memory of details from the film (α=.73). The execution time of the first task was limited to 4 minutes. There was no time limit for completing a memory questionnaire. In this study the average internal consistency reliability (Cronbach's alpha) for pre-film and post-film subjective tense arousal was .88 and .87. respectively.

Results

Preliminary results

Kolmogorov–Smirnov tests revealed that all the variables tested were normally distributed. Descriptive statistics (M and SD) for all measures are reported in Table 2. The results showed that participants in the suppression condition experienced a significantly higher post- than pre-film tense arousal [t(29) = 4.38, p < .001, Cohen's d = .79]. Participants in the control condition also declared higher post-film tense arousal compared to the pre-film tense arousal, but the difference did not reach conventional levels of statistical significance (p = .16). Consequently, the increase in tense arousal was significantly higher in suppression condition t(58)= 2,34, p < .05, Cohen's d = .58]. As predicted, the suppressors performed the anagrams task significantly poorer than the controls: t(58) = 4.35, p < .001, Cohen's d = .98. Furthermore, the suppressors remembered on average 20% less of the film content than participants in the control condition: t(58) = 5.27, p < .001, Cohen's d = 1.13. We also observed that scoring on the anagrams task correlated negatively with post-film tense arousal (r = –.52, p < .001) and change (i.e., an increase) in tense arousal (r = –.58, p < .001). Pre-film tense arousal and performance on the anagrams task were not correlated. Scoring on the memory questionnaire correlated negatively with post-film tense arousal (r = –.55, p < .001) and an increase in tense arousal (r = –.53, p < .001). Pre-film tense arousal and performance on the anagrams task were not correlated. There were no significant gender differences in the performance of cognitive tasks and mood dimensions, thus gender was excluded from the analysis.

Main results

Did subjective tense arousal mediate the effects of expressive suppression on the anagrams task performance?

In the first step we tested whether the experimental condition, coded in the same way as in the Study 1, was a significant predictor of the anagram task performance. The results confirmed this prediction: β = –.49, p < .001. In the second step, we used the experimental condition variable to predict participants' increase in tense arousal. This path was significant as well, β = .29, p < .05. As a final step, we simultaneously entered the experimental condition variable and increase in tense arousal into a multiple regression predicting performance in the anagram task. When increase in tense arousal entered the equation, it significantly predicted the anagram task performance, β = –.47, p < .001, and reduced the beta weight for experimental condition, β = –.36, p < .01. Therefore, following Baron and Kenny's (1986) criteria for mediation, partial mediation was indicated. A Sobel test, obtained using procedures developed by Preacher and Hayes (2004), confirmed partial mediation (*z* = 2.08, p< .05). The mediation analysis demonstrated that suppression directly and indirectly (through increase in subjective tense arousal) relates to the anagram task performance (see Figure 2).

Table 2. Means and standard deviations of arousal measures and the cognitive performance for each condition

Measures	Control		Suppression	
	M	SD	M	SD
Pre-film tense arousal	16.97	5.74	16.37	4.06
Post-film tense arousal	18.17	4.56	20.50	6.20
Change in tense arousal (increase)	1.20	4.54	4.13	4.55
Film memory (%)	81.04	11.19	61.04	17.50
Anagrams	19.83	3.45	15.13	4.82

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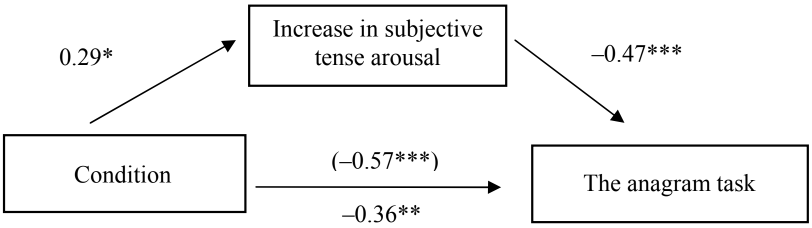
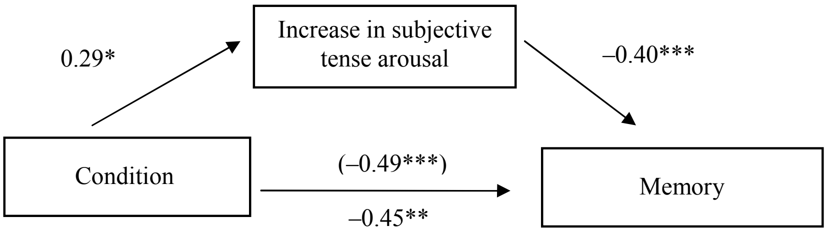
Figure 2. Increase in tense arousal as a mediator of the effect of experimental condition (contrast coded) on cognitive performance as measured with the anagram task. Values represent standardized regression coefficients. The regression coefficient in parentheses refers to the direct (unmediated) effect of experimental condition when not controlling for the increase in tense arousal.



* p < .05, ** p < .01, *** p < .001

Figure 3. Increase in tense arousal as a mediator of the effect of experimental condition (contrast coded) on memory of the events that occurred during the suppression period. Values represent standardized regression coefficients. The regression coefficient in parentheses refers to the direct (unmediated) effect of experimental condition when not controlling for the increase in tense arousal.



* p < .05, ** p < .01, *** p < .001

Did subjective tense arousal mediate the effects of expressive suppression on memory?

In the first step we tested whether the experimental condition was a significant predictor of memory of the events that occurred during the suppression period. As predicted, this was the case, β = –.57, p < .001. When increase in tense arousal entered the equation, it significantly predicted scoring on memory, β = –.40, p < .001, and reduced the beta weight for the experimental condition, β = –.45, p < .001. This drop was significant as evidenced by a Sobel test, z = 1.97, p < .05. Therefore, the mediation analysis demonstrated that suppression directly and indirectly (through an increase in subjective tense arousal) relates to memory of the events that occurred during the suppression period (see Figure 3).

Discussion

The aim of this paper was to contribute to a better understanding of the cognitive consequences of ES. Specifically, we examined whether the deteriorating effect of ES on cognitive functioning is caused by tense arousal enhanced by suppression. The results of two experiments support our prediction and lead to three major conclusions.

First, the results reveal that ES undermines cognitive functioning. We observed that ES leads to poorer performance on WM tasks, as measured with a backwards digit-span task (Study 1) and anagram problem-solving task (Study 2). We also observed that ES degrades memory of the events that emerged during the period of ES (Study 2). These results are not surprising as they are consistent with the bulk of previous studies (e.g., Bonanno et al., 2004; Baumeister et al., 1998; Richards & Gross, 1999; Schmeichel et al., 2003).

Second, the results indicate that ES of negative emotions (i.e., disgust in Study 1 and a combination of fear, sadness, and anxiety in Study 2) leads to a significant increase in subjective tense arousal. It is noteworthy that although no-regulation participants also declared higher post-film tense arousal compared to the pre-film tense arousal the increase in tense arousal was significantly higher in the suppression condition. These results are in line with studies using physiological indicators of arousal (Harris, 2001; Richards & Gross, 1999). However, to our knowledge, this is the first study demonstrating that ES results in an increase in subjective feelings of arousal.

Third, the results support our prediction that ES decreases cognitive performance through its effects on subjective tense arousal. The results of Study 1 show that tense arousal activated during ES fully mediates the negative effect of suppression on working memory as measured with a backwards digit-span task. The results

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of Study 2 reveal that subjective tense arousal partially mediates the effect of suppression on both the WM (as measured with the anagram task) and memory of the events that occurred during the suppression period. To the best of our knowledge there is only one study, conducted by Richards and Gross (1999), that tested whether arousal mediates the deteriorating impact of ES on cognitive functioning. The results of their study revealed that arousal was heightened by ES, but mediational analyses demonstrated that psychological and cognitive effects were independent. We need to remember, however, that Richards and Gross (1999) used in their study physiological indicators of arousal, i.e., blood pressure and finger temperature. Hence, the inconsistency of our and their results is probably due to the use of different measures of arousal (physiological vs. self-report). The discrepancies between physiological and psychological indicators of arousal were discussed earlier in this article.

Although the outcomes of our studies converge to some extent, we didn't succeed in obtaining a full replication of the results. Both studies demonstrate that an increase in subjective tense arousal mediates the impact of ES on WM, however, Study 1 resulted in full and Study 2 in partial mediation. Therefore, we can ask what caused this difference in the results. We argue that it is due to different emotions elicited in each study. The movie used in the Study 1 elicited disgust and the movie used in the Study 2 elicited mainly sadness and anxiety. Research shows that various emotions utilize cognitive resources to a different degree. This hypothesis was confirmed in our previous studies (Kocowski, Kofta, Maruszewski, & Pleszewski, 1970). Moreover, although in both movies the motive of loss was dominant, only the movie in Study 1 elicited stenic emotion. Disgust is a highly arousing, unpleasant emotion that elicits an intense visceral response and an immediate physiological action, connected with the functions of the gastrointestinal tract, e.g., keeping control over nausea (Haidt, McCauley, & Rozin, 1994). We can assume, therefore, that concealing disgust may lead to a greater increase in arousal than concealing sadness/anxiety and thus it drains cognitive resources needed to perform WM tasks to a greater extent. In this vein, the full mediation between ES and decrease in cognitive performance, obtained in the Study (i.e., where disgust was induced), and partial mediation revealed in Study 2 (i.e., where mainly anxiety and sadness were induced) is quite understandable.

Taken together, the results of our study show that the deleterious effects of ES on cognitive functioning are due to subjective tense arousal enhanced by suppression. Going further, it can be assumed that suppressing emotional reactions consumes attentional resources and this in turn deteriorates cognitive performance. Such an interpretation is consistent with be the cue-utilization theory of Easterbrook (1959) and previous research showing that intense negative affective states reduce available attentional resources for performing prospective tasks (Ellis & Ashbrook, 1988; Eysenck & Calvo, 1992).

Alternative explanations

The current findings do not exclude alternative explanations of the mechanism by which suppression consumes cognitive resources. Two other theoretical propositions should be mentioned here: the cybernetic process model of self-control and the ego-depletion paradigm.

Magen and Gross (2010a, 2000b) explain the detrimental effect of suppression on memory from the perspective of the cybernetic process model of self-control, which represents a synthesis of two earlier models: the cybernetic control model of self-regulation (Carver & Scheier, 1981; Larsen, 2000) and the process model of emotion regulation (Gross, 1998a; Gross & Thompson, 2007). The former focuses on regulation of the extrapersonal, whereas the latter focuses on regulation of the interpersonal realm. Specifically, the cybernetic control model of self-regulation refers to ways in which impulses are externally regulated and the environment is shaped, whereas the process model of emotion regulation refers to ways in which such impulses may be self-regulated and behavior may be shaped (Magen & Gross, 2010a, 2010b). According to the cybernetic process model of self-control, efforts to uphold or change behavior evoke a negative feedback loop by which the existing condition of a system (e.g., the expression on one's face) is compared to a behavioral standard or goal (e.g., wanting to appear calm and emotionally neutral). If a discrepancy is detected between them (e.g., grimacing and scowling when one wants to appear calm and emotionally neutral), self-monitoring and self-corrective processes are triggered in order to reduce this discrepancy and accomplish the desired state or behavior (e.g., appearing calm and neutral). It should be noted, however, that although these self-monitoring and self-corrective processes help people achieve their goals, e.g., look composed while irritated inside, but at the same time may consume attentional resources needed for other simultaneously performed tasks. As a result, performance on these latter tasks can be poorer. Therefore, Richards and Gross (2006) assume that people who hide their emotional expression during an emotional event encode less information, and as a result, remember the event worse than people who freely express their feelings. This explanation of the unfavorable effect of suppression on memory seems to be highly convincing given that memory impairment is stronger among people who report putting more effort into suppression than people who put relatively less effort into suppression (Richards & Gross, 2006).

The deteriorating effect of ES on subsequent cognitive performance is usually explained in terms of the ego-depletion paradigm (Baumeister, Bratslavsky, Muraven and Tice, 1998). According to the ego-depletion view (Baumeister et al., 1998), people have a limited pool of mental resources that can be used up. This central resource, parallel to ‘‘energy'' or ‘‘strength'', is consumed by tasks that require controlled, intentional action. In the view of Baumeister and colleagues (1998) exerting self-control in one task impairs performance on subsequent unrelated

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tasks requiring the same resource (see also Buczny, Layton, & Muraven, 2015; Kadzikowska-Wrzosek, 2010, 2013). Therefore, from the perspective of the ego-depletion view, the decline in cognitive performance following ES is quite understandable. Let us remember that ES is considered to be a very effortful emotion regulation strategy, as it requires one to engage in behavioral initiation and inhibition, attentional control, and self-monitoring and self-corrective processes (Gross & Thompson, 2007). Additionally, suppression involves controlling emotional reactions while already physiologically aroused (Gross & Levenson, 1993).

Expressive suppression and working memory

Our research shows that ES affects the WM when its efficiency is measured both by the solving anagrams task and a backward digit span task. This is an important finding because these two tasks measure somewhat different aspects of the WM. Performance of the backward digit span task is regarded as a manifestation of the efficiency of the phonological loop (Pickering & Gathercole, 2001; Piotrowski, Stettner, Wierzchoń, Balas, & Bielecki, 2009). However, part of this task – namely reversing digit sequence, is processed by the central executive and the rules of the transformation of the digits are strictly defined. It means that in this task the activity of the central executive has to be flexible. In contrast, the anagrams solving task does not involve the mnemonic function of the WM, but the rules of transformations are less strict. In addition, in the anagrams task, participants know whether they succeeded (i.e., participants know how many anagrams they managed to solve), while in the backward digit span task participants are usually not aware of their results.

It is noteworthy that solving anagrams involves two stages. The first stage includes the application of heuristics governing selection from the possible set of letters. In the Polish language consonants and vowels occur in specific combinations: two or three consonants together are less frequent than a combination of two consonants with a vowel between them. Some of the vowels may also coincide (e.g. *i* and a; *i* and *e*; *a* and *u*), while other are quite rare (*o* and *e*). Therefore, participants may start with building blocks of two or three letters that may comprise the final five letter string. The second stage involves the assessment of the chosen solution. When a five letter string is found (after a transformation of the initial set of letters), the new string of letters has to be compared with word representations in an internal lexicon. In some cases a new string of letters does not fit to any representation and must be discarded. Subjects may have used various strategies of dealing with anagrams. Some of them may have started with two letter strings (consonant plus vowel) and some with three letters strings. These strategies provide various numbers of degrees of freedom and offer more or less divergent ways of dealing with the task. This means that solving anagrams may be considered as task of various levels of difficulty. This difficulty is controlled by the subject who chooses a particular strategy of solution (e.g., use of two- or three-letters blocks). To examine more sophisticated hypotheses concerning the impact of suppression on WM performance, i.e., that difficult tasks are more affected by ES than easy tasks, the difficulty of a task should be controlled by the experimenter not by the subject.

Investigating the WM and suppression relationship is a promising area of research because it is already known that both WM and suppression of emotional responses are governed by the similar brain structures, i.e., frontoparietal circuitry and subgenual anterior cingulate cortex (Schmeichel, Volokhov, & Demaree, 2008). Schmeichel et al. (2008) also found that there is a correlation between individual differences in WM and the ability to regulate both positive and negative emotions (see also Ochsner & Gross, 2008).

Future directions of research

The results of our study are based on relatively simple methods of determining functions of the WM. Because ES is connected with functions of the central executive, future research should include tasks indicating the activity of this aspect of the WM (Hofmann, Friese, Schmeichel, & Baddeley, 2011). For example, such tasks as n-back that require active information processing – continuous refreshing and updating of WM. ES requires similar functions, because besides controlling reactions to inconstant situational demands one has to also control his or her own expression and to adjust the strength of this control to previously obtained results. If earlier results were unsuccessful, control should be strengthened and at the same time deterioration of WM should be more pronounced.

Future research should also take into account emotional vs. neutral content of WM. Most previous studies used methods that included neutral content – e.g., digits, anagrams, neutral words, etc. It is interesting whether emotional suppression exerts its impact on any content of WM or whether it influences only non-emotional content. N-1 task in standard form requires only refreshing and updating memory of letters; by changing this task into an emotional one – where instead of letters faces with various emotional expressions are used – may give another pattern of results (Levens & Gotlib, 2012). It poses a new question: if emotional suppression of one's own emotions changes information processing concerning the emotions of other people. We have evidence that this line of research is promising (Szczygieł et al., 2012).

We are also convinced that when relating arousal to cognitive performance an important source of variation are individual differences in dispositional affectivity (Brzozowski, 2010) as well as temperament (Fajkowska, Wytykowska, & Riemann, 2012; Müller & Wytykowska, 2005). Another dispositional variable, which could be counted as a possible moderator of the relationship between ES and cognitive performance is emotional intelligence. Results of several studies provide evidence that emotional intelligence is a particularly useful construct to assess individual differences in emotion regulation (Mikolajczak & Luminet, 2008; Mikolajczak, Luminet, & Menil, 2006; Szczygieł & Bazińska, 2013; Szczygieł & Kolańczyk,

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2000). We also need to remember that performance on WM tasks continuously declines with age (Maruszewski, 2011; Szczygieł & Jasielska, 2008). Moreover, studies show gender and age differences in emotion regulation (Jasielska, 2011; Jasielska & Szczygieł, 2007; Riediger et al., 2014; Szczygieł, 2007). It is possible to omit individual differences by randomly assigning participants to affective manipulations, but a more powerful design should attempt to take these individual differences into account. Such an approach increases statistical power of the study and leads to a clearer understanding of the relationships between affect, arousal, and cognitive functioning (for discussion, see Revelle & Loftus, 1992).

We would like to mention that phenomena considered in this paper are closely linked to thought suppression (Wegner, 1994). Control processes may operate both on emotional and neutral content. It may be hypothesized that the more effort is needed to control emotional expression or some unwanted thoughts, the greater deterioration of central executive functions. This hypothesis should be verified in future studies. It could also offer some extension to the idea of ironic control processes.

Concluding comment

Previous researcher emphasizes that cognition and emotion influence each other (e.g., Kolańczyk, 1997; Maruszewski, 2007). The present study contributes to a better understanding of the mechanism underlying the effects of ES on cognitive performance. We have demonstrated that ES produces not only cognitive consequences but also consequences in subjective experience of tense arousal. Furthermore, we found that subjective tense arousal mediates cognitive consequences of suppression. This leads us to the conclusion that suppression is an expensive way to regulate emotions. Does it mean that suppression should be considered an ineffective or dysfunctional emotion regulation strategy?

Emotion regulation helps to achieve individual goals by manipulating and modulating emotional responses. Which emotion regulation strategy is chosen depends both on characteristics of the person (i.e., temperamental factors, emotion regulation competencies) and the characteristics of a particular situation (Jasielska, 2013). Situational settings differ with respect to a range of available behavioral choices and options for interpretation. Moreover, the behavioral options are usually constrained by cultural and social norms (Fisher, Manstead, Evers, Timmers, & Valk, 2004). One emotion regulation strategy may be functional in some situations but dysfunctional in the others. The need to temporarily engage in ES is pervasive in everyday life, and the proper (i.e., context-appropriate) use of ES serves social goals and is associated with positive interpersonal functioning (Butler & Gross, 2004). For example, service workers are obliged to manage their emotions in order to display organizationally desired emotions and very often they do it by ES (Baka & Derbis, 2013; Bazińska, Kadzikowska-Wrzosek, Retowski, & Szczygieł, 2010; Szczygieł & Bazińska, 2012; Szczygieł, Bazińska, Kadzikowska-Wrzosek, & Retowski, 2009). We all know that sometimes the only way to manage emotions is to bite the bullet and make the best of a bad job. However, our research demonstrates that concealing feelings, despite having its undoubted merits, has its price.

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