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Suppressing behaviour related to discomfort induced with a cold pressure task does not influence working memory capacity in a 2-back task.

Erik Danielski

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Supervisors: Martin Wolgast & Emelie Stiernströmer

Abstract

The study aims to examine the impact of Expressive Suppression (ES), on Working Memory (WM) performance when exposed to mild pain reaction causing physiological activation. Performance measures are obtained to discriminate between three groups having their hands in warm water, cold water, and cold water and implementing ES. As a measure of WM performance, this study used a WM 2-back task interspersed with emotionally positive, negative and neutral faces. This study predicted the detrimental effect in WM performance when implementing ES, in line with previous studies suggesting that suppressing behaviour is cognitively effortful (Richards and Gross, 2000). However, in contrast to our predictions, our results indicate no trade off in accuracy measures processing information in the 2-back task while simultaneously implementing ES. In addition, subjective ratings using the SAM-scale (Bradley & Lang, 1994) were gathered and the discomfort-related behavioural data rated by an independent group of students. The SAM-scale data suggest that being exposed to cold water CPT evoked less positive affect but not when implementing ES on CPT. Objective ratings suggest that there was a difference in participants behaviour and that implementing ES resulted in lower dispositional behaviour. Qualitative results also contribute to our understanding of the impact ES has on WM, even though they can be questioned. Therefore alternative explanations are discussed and manipulation implementation is questioned.

Keywords: Emotion, Emotion Regulation, Expressive Suppression, Working Memory

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Emotion Regulation (ER) is referring to the ability to up- or down-regulate emotions, and has a longstanding history where early philosophers as well as later psychologist have discussed the importance and implications of handling emotions (Gross, 2013). From the last twenty years of research it is clear that a need to understand emotions and especially regulation of emotions that are destructive or maladaptive is needed. From the last years upsurge of publications in the ER field (Gross, 2013) a need to continue and examine the impact of some central concepts of ER is the future direction. Especially, since some ER strategies are considered to be less favourable or adaptive than others (Sheppes & Gross, 2011). This study will deal with one central concept in recent research of ER as a part of James J. Gross´s process model, ES is defined as suppressing of behaviour and is considered to be less favourable as an ER strategy over other strategies and detrimental for cognitive performance (Richards & Gross, 2000) and in the context of this study, thought to lower memory performance. WM can hence be considered a memory process that retains information for a short period of time (Baddeley, 2003) not necessarily related to pieces of information, on one side visual and spatial or on the other phonological, but as a continual flow of information limited in duration (Feldman Barrett, Tugade & Engle, 2004).

Considering the above, this study will focus on the interaction between ES, working memory capacity and emotion. Specifically, we investigate whether ES predict lower WM performance compared to baseline measured in a classical WM 2-back task (Lindström & Bohlin, 2011). For this purpose, a conceptualisation of emotion is followed by a discussion of ER as a concept and as a process model, followed by a conceptualisation of ES and a discussion of how emotions influence WM.

A conceptualisation of emotion

Emotion in contemporary science is hard to define and therefore important to conceptualise (Gross & Feldman Barrett, 2011). The definition of emotion used here relies on an evolutionary grounded concept where emotion serves as a survival function (Ledoux, 2012). Also included in this concept are neurological underpinnings (Damasio & Carvalho, 2013), which becomes important when a distinction is made between top-down and bottom-up generated emotions. As described in the literature top-down emotions are when an appraisal of a stimulus generates an emotion, while bottom-up emotions are seen as bodily experienced, faster and uncontrolled. This conceptualisation of emotion also involves the circumplex model, where valence range from positive to negative and arousal from high to

low activation and together represent four dimensions (Gerber et al., 2008). Emotions are multifaceted and hence hard to validly operationalise in a single experiment. One way to view emotions are as bodily activation provoked by a controlled stimulus. A cold pressure task (CPT) has previously been used as a way of provoking a mild pain reaction (Lovallo, 1975; Schwabe, Haddad & Schachinger, 2008). and as a tool to study the impact emotion has on cognitive performance, especially in terms of memory (Smeets, 2011; Smeets, Otgaar, Candel & Wolf, 2008). The pain reaction is used to create a physiological activation, proven to co-vary with subjective measures of the two dimensions of emotion, valence and arousal (Bernat, Cadwallader, Seo, Vizueta & Patrick 2011). Since emotions affect cognitive performance, they are important to regulate. Dys-regulation of emotion has shown to be closely interconnected to psychopathological disorders (American Psychiatric Association, 1994) and have instigated theoretical models such as the process model of emotion regulation.

A process model of Emotion Regulation

ER is a goal driven process from an internal or external perspective where the intensity and duration of an emotion is regulated (Gross, 2013). ER can be viewed as intra- or interpersonal activation depending on the cause of the emotion (Bonanno, Pat-Horenczyk & Noll, 2011; Ursache, Blair, Stifter & Vogegtline, 2013). ER can also be seen as an effortful or effortless process and be automatic or controlled (Mauss, Cook & Gross, 2006), which is either conscious or unconscious (John & Gross, 2004; Richards & Gross, 2000). The discussion has also been concerning, whether it is preferable from a social context of recognising threatening situations (Blechert, Sheppes, Di Tella, Williams & Gross, 2012) and how the situation might provoke different ER strategies depending on the intensity of the stimuli (Sheppes, Scheibe, Suri & Gross, 2011).

One-way of looking at ER is as a process up- and down regulating emotion and was first described as a model by Gross, (1998a; 1998b; 2001) and Ochsner and Gross (2008). In a series of articles James Gross and colleagues, argue that emotion needs to be regulated and that this can be seen as a process with different strategies to modulate the emotional response (Mauss, Cook and Gross, 2006). Gross (1999) emphasises the importance of separating regulating by emotion from regulating of emotion. The distinction needed is because regulation of emotion is proposed to be critical over time contrary to regulating by emotion. Regulating of emotion is hence done on a moment-to-moment basis in a short time frame to serve a purpose, reach a goal, and serve the person regulating the emotion in a longer time

perspective of well-being (Gross & John, 2003). Even though such a long time perspective does not exist in an experimental situation, the concept of ES described below and used here is categorised as regulation of emotion because of the theoretical connection to the process model and because down regulation of behaviour previously has been shown to regulate emotions (Gross & Levenson 1993). Regulating by emotion on the other hand does not have a longer time frame where i.e. laughing in excess or crying to reach a goal is not considered to be important and supposedly not having implications in a longer perspective of well-being. This divide also means that ER is thought to be moderated on different levels of abstraction, where both inter- and intrapersonal regulation is to be decisive of which specific strategies that are to be used (Gross, 1998a; John & Gross, 2004). The process model of ER consists of two broad groups of regulatory strategies focusing on two different points in the emotion generating process or the expected trajectory that an emotion can be interpreted as. The first group is called the antecedent focused and consists of *situation selection, situation modification, attention deployment* and *cognitive change* as categories, which in turn incorporate different strategies (Gross, 1998a). These strategies focus on the earlier modification of the trajectory and emphasise a down- or up-regulation of emotion before it becomes a behavioural response. The antecedent strategy most commonly discussed is *reappraisal*, which relies on cognitive change and basically means to think about stimuli in a different way. The second group is the response-focused strategies where focus is put on the later part of the emotion trajectory. That is when the emotion has been evoked and is underway, these strategies work as a down- or up-regulation of the responses to adjust the trajectory. Gross (1998a) suggests that there are three different levels where the modification of emotion operates at this stage, the *behavioural* level, the *experiential* level and the *physiological* level. Using response-focused strategies might sometimes be preferable when emotions cannot be displayed or expressed. The response-focused strategy discussed most in contemporary research is ES. Since there is a lack of understanding in regard to what ES is to be considered, ES is the focus of this study and discussed in depth further down.

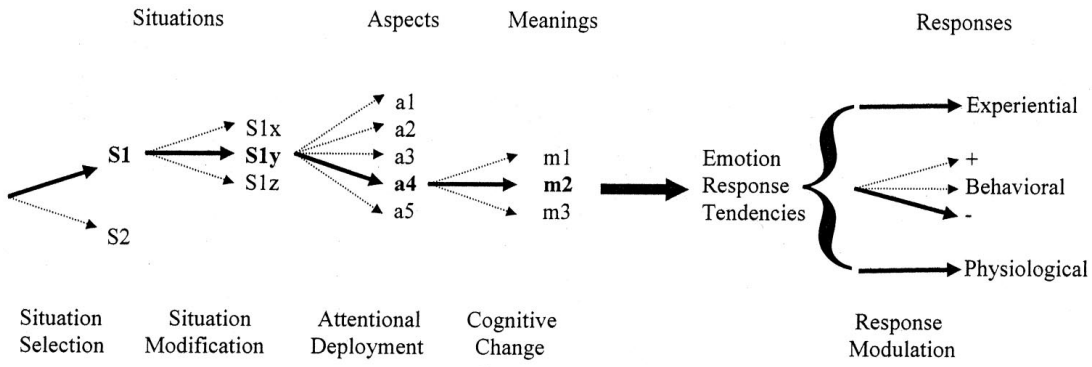

Figure 1. A process model of emotion regulation depicted by Gross (1998a; 1998b; 2001). Copyright by Sage Publications, reprinted with permission.

Expressive Suppression

Suppressing behaviour or emotional expression might be a good thing in some social situations i.e. talking in front of a group or encountering threats (Bonanno, Papa, Lalande, Westphal & Coifman, 2004). Doing the opposite, enhancing behaviour or expression, might also serve a purpose in some situations. Research has shown that suppressing behaviour and emotional expression does not necessarily lead to a difference in behaviour but leads to heightened cardiovascular activation and elevated blood pressure (Gross & Levenson, 1993). ES is therefore considered as an internal change due to external withholding of behaviour or emotional expression (Bonanno et al. 2004), described as, *" . . . asking participants to suppress only the behavioural expression of disgust elicited by a video may limit behaviour while boosting autonomic responding and leaving experience unchanged"* (Ochsner & Gross, 2008, p. 154). Thus, the operationalisation of ES used here is a lack of external behaviour that causes internal physiological responses.

Few studies have yet focused on the subcomponents of ES and it is not clear what cognitive operations are involved in ES (Aldao & Nolen-Hoeksma, 2012). It has been documented how a short lived emotional reaction of arousal is elevated for participants using ES but no effect was found in regard to valence. The observed effect dissipated faster than previously thought when measured as a function of self assessed stress, suggesting that ES might not have the prolonged and detrimental effects previously proposed (Meyer, Smeets, Giesbrecht, & Merckelbach, 2012).

When instructed to use different ER strategies such as ES and reappraisal when focusing on emotion eliciting pictures have supported attention as a mediator for ER

strategies. Using eye-tracking technique to measure gaze, participants were asked to attend to pictures and implement an ER strategy. Results showed that ES was associated with not attending contrary to reappraisal (Bebko, Franconeri, Ochsner & Chiao, 2011; Urry, 2010). This was further supported in a study by Goldin, McRae, Ramel and Gross (2008) using fMRI to compare antecedent focused strategies with response-focused strategies and found that reappraisal included PFC regions previously reported to be implicated in antecedent focused strategies and showed that the onset of these strategies could be identified within seconds in the PFC, making the argument that a decrease in the BOLD signal observed ten to fifteen seconds later in subcortical regions such as the insula and amygdala were caused by an inhibition by PFC. When comparing this data with ES, areas implicated were partly regions of motor control, occipital areas including visual perception and some PFC areas associated with motor-inhibition control. Thus, Goldin et al. (2008) argue that subcortical regions were not inhibited by a cognitive function rendering a lack of emotional activation in ES, and were taken as support for previous conclusions with inhibiting behaviour leading to increased physiological activation.

As can be seen from the above, ES as an ER strategy is closely linked to differences in the degree to which individuals express their emotions. The variation can be viewed as a learned process where society limited or enhanced the degree to what extent a person felt compelled to express his/her emotions as a child and has become a learned behaviour. Craig et al. (2010) discuss the automatic and controlled aspects of expression of pain and conclude that understanding pain in others differs whether the expression appears to be controlled or automatic: Whereas the perceiver might question controlled expressions of pain, an automatic reaction is more likely to provoke empathy. Using this reasoning, ES can be argued to have large social implications, if withholding of behaviour in ES is perceived as deliberate controlling of emotions. One study has documented a naturally occurring variation in use of ES or expression of emotion. The documented pattern of brain activation suggests a difference in voluntary use of ES and expression of emotions. Voluntary inhibition of pain is thus suggested to recruit PFC regions and includes the mPFC while expression of emotions involve previously known areas for emotion processing (Kunz, Chen Lautenbacher, Vachon-Pressau & Rainville, 2011). Suggested from the study is a difference in that humans vary in degree of expressing or withholding emotions and that this is possibly a learnt strategy. Another study, focusing on chronic pain patients showed that when rating facial expressions (joy, fear and pain), the chronic pain patients identified all emotions but rated painful facial

expressions as less positive and more arousing than others. This is discussed as an attention bias where patients might identify and hence rate painful expressions more accurately and possibly have implications for automatically recruiting of ES as a strategy of down-regulating behaviour (Reicherts et al., 2012).

Culture and context have proven to be important moderators of ES. I.e. Goldstein, Tamir and Winner, (2012) used an acting class at a high school in the US where the acting class was contrasted against a class from another creative subject at the same school. Results showed that students in acting classes used ES to a lesser extent than did other students. When students got to take acting classes the use of ES as strategy decreased. Interpretation of these findings should be done cautiously, since no randomisation was used and problems with confounding variables regarding personality and motivation could be playing a role. Building on the difference of use in ES, scholars have also documented a cultural difference (Soto, Perez, Kim, Lee and Minnick, 2011). A comparison between Chinese and American students in usage of ES showed how, in China, students do not use ES as a way of regulating emotions to the same extent as students in the US. Results suggest that there might be differences in regard to the extension ES is used in different cultures and hence needs to be accounted for. Another important distinction was made by Aldao (2013), Campos, Frankel and Camras (2004), and Campos et al. (2011), they discuss contextual influences on ER and how this could call for a re-conceptualisation of the ER concept, stressing the need to be aware of the low ecological validity often used in experimental settings and that it is possibly more important than previously assumed. In need of attention in a discussion of ES as detrimental is the discussion of regulation from an intrapersonal perspective or from a social perspective, emphasising the social and goal oriented explanation of regulation as an important factor. No such answer exists so far, but a discussion is of great importance as it guides research in a direction of realistic proportions (Aldao, 2013; Campos et al., 2011). One way to study ES from an intrapersonal perspective and in a controlled environment is by examining performance measures of WM.

Emotion, Working Memory and Expressive Suppression

Emotional stimuli have proven to affect WM processing (Kensinger & Corkin, 2003; Lindström & Bohlin, 2011; Stiernströmer and Johansson, 2013) Lindström and Bohlin, (2011) found an emotional enhancement effect when using a 2-back paradigm to test how emotional faces affected cognitive processing. Results showed how negative facial expressions facilitate

WM, and that there was neither effect on positive or neutral faces. Further results from another study found that emotional (negative and positive compared to neutral) facial expressions provoked a more liberal response bias and that negative facial expressions generated shorter reaction times (Stiernströmer & Johansson, 2013). Research has also shown that both negative and positive valence can facilitate WM and is suggested to hinge on the possibility to shift attention away from the stimuli (Gotoh, Kikuchi & Olofsson, 2010). Other studies have shown how negative valence stimuli have detrimental effects on WM and have also been associated with impairment in shifting attention, though if attention stays too long at one stimuli it affects binding and in turn lowers relational memory recognition (Mather et al., 2006). Enhancement or impairment has also been hypothesised to depend on the type of stimuli used in experiments, i.e. exposure to emotional faces differs from emotional words (Banich et al., 2009; Gotoh, Kikuchi & Olofsson, 2010). Some studies question the oversimplification of valence as detrimental, and use arousal with negative or positive valence as determinants of an enhanced or impaired function of arousal on cognitive capacity, in terms of WM (Bergmann, Rijkpema, Fernández & Kessels, 2012; Levens & Phelps, 2008).

Examining current positions of WM and ER a discussion on differentiating between positive or negative valence and un-aroused or aroused stimuli and states is important. It has been suggested that an arousing state alone cannot account for an enhancement effect on memory performance. Rather it seems that an interaction between state-arousal with a positive or negative valence stimuli is needed (Greene, Bahri & Soto, 2010). Even so, an arousal state has often been associated with an enhancing effect on cognitive capacity (Esmaeili et al., 2011; Nashiro & Mather, 2012) and this effect has been supported from neurological studies suggesting unique brain activation for emotional eliciting stimuli contrary to non-emotional stimuli (Osaka, Yaoi, Minamoto & Osaka, 2013). Stress in terms of a mild pain reaction causing a stress induced physiological response has proven to enhance memory recognition but impair memory retrieval in a long-term memory test, rendering some support of how a state of arousal have a positive affect on source memory binding while impairing relational memory binding (Smeets et al., 2008). Given these results, an aroused state should predict enhanced cognitive capacity in terms of source memory and accuracy measures, though it might depend on the nature of the stimuli as positive or negative in terms of positive or negative valence and instead impair relational memory recognition through impaired binding, mediated by attention (Mather, 2007).

Bonanno et al. (2004) conducted a study on memory and ES, where results showed that lowering or enhancing the use of ES, as have been described in behavioural terms impaired WM capacity. Richards and Gross (2000) present similar findings where they demonstrate how ES stole cognitive capacity from WM in a verbal memory test. Participants viewed a film and were asked to remember details from the film and to implement different strategies of ER. Results showed that the use of ES lead to lower memory performance in terms of remembering details from the film, contrary to the use of other ER strategies such as reappraisal. Richards and Gross (2000) conclude that this happens because of a need to be self-evaluative when implementing ES and that this process becomes effortful and detrimental for WM performance in terms of capacity. Thus, the connection between WM and ES has proved to be important and relatively unexplored with contradictory results (Holland & Kensinger, 2012). In the literature there is an understanding that WM performance is impaired when implementing ES as ER strategy. However, satisfying understanding of how this happens has not been obtained and questions what ES is to be considered. This is what the current study will examine from here on.

Purpose and Hypothesis

The aim of this study is to investigate if implementing ES becomes detrimental in terms of WM performance. In addition, the group implementing ES was asked a question to describe how they implemented the instructions of withholding behaviour and is used to highlight sub-components of ES as theoretical concept. The novelties of this study consist of two parts, 1. Instead of testing WM capacity in ES using an auditory memory task, a 2-back task measuring accuracy and response bias as performance measures was used and, 2. Sub-components of ES to describe the cognitive operation involved in suppressing behaviour in regard to induced discomfort are highlighted, that is, to capture how participants implement the instruction to suppress behaviour. Hypotheses under investigation were:

1. Valence is experienced as more negative when having a hand in cold water, independent of other manipulations.
2. A higher level of subjective arousal is experienced by the ES group.
3. Participants show less emotional behaviour implementing ES as ER strategy.
4. ES steals cognitive capacity in terms of worse accuracy results when conducting a 2-back task.

Method

Participants

Students from undergraduate, graduate and college courses were selected using social-media and by personal inquiry. Organisations from outside the campus were visited and asked to participate in the experiment. 84 participants (N=84), participated in this experiment (28 in each group) where 70.2% were female (N=59), two participants were excluded from the analysis due to neuropsychiatric diagnoses. There were no significant gender differences between the groups, $\chi^2(2, N = 84) = 3{,}19$, $p=.2$. Participants´ mean age was (M=35.34 SD=12.05) and there was not a significant difference between groups: $F(2, 81) = 0.1$, $p=.95$. Participants were asked to be part of a WM study where they responded by pushing a button and were told that they might be subjected to coldness. All participants were asked to sign a consent form that they would be randomised into different groups and that they could leave the experiment at any time. Group 1 (G1) was asked to conduct the 2-back task and had their hand in room-temperature water and rated their experience on a SAM-scale. Group 2 (G2) was subjected to the CPT and rated their experience and conduct the 2-back task. Group 3 (G3) was subjected to the CPT, rating experience, conducting the 2-back task and were instructed to implement ES. Inducing pain has some ethical complications. Due to the need for physiological arousal in a sixteen-minute-time-period when conducting the 2-back task and the need for equal amount of time for control group, participants were informed of the manipulation and that it might be uncomfortable. Four people chose to participate but decided to abort during trial period.

Material

Cold Pressure Task. In order to study ES and its effect on WM, there was a need to evoke a certain level of physiological arousal that could be suppressed. In the present study a modified CPT was used. The modification consists of a higher temperature than previous studies have used due to the longer time of activation needed. In this study the time needed was approximately 16 minutes depending on how fast participants were conducting the 2-back task. Therefore the water had a temperature of eleven degrees Celsius at the onset of the test when participants put their arm in the water. The temperature then rose as a function of bodily heat and time. G1 conducting the same 2-back task with their hand in room tempered water. In order to ensure the exact temperature a waterproof digital multi-thermometer was used.

SAM-Scale. To rate the experienced emotion of the CPT a previously known method called a SAM-scale was used (Bradley & Lang, 1994). This tool allows a measure on valence and arousal dimensions using six items for each factor. The scale proved reliable for each group and as an overall measure of both factors. To control for reliability Cronbach´s alpha was calculated for both dimensions for each group and as an overall measure, displayed in Table 1.

Table 1.

Reliability measures using Cronbach´s alpha for each group and as an overall measure of the SAM-scale.

	Arousal	Valence
G1	84,2	88,7
G2	76,9	91,3
G3	51,4	76,0
Overall	75,2	87,3

WM-task. The 2-back task was conducted using a Cedrus box RB-730, compatible with E-prime and used to collect responses. Data were gathered using the primary hand for all participants and response keys were switched between each participant to control for a difference in reaction between fingers. The procedure of the 2-back task was to identify emotional faces as they appeared on a 15-inch computer screen and when the target face was observed as the face that appeared two faces before participants were instructed to press YES, when a non-target was displayed they were told to press NO.

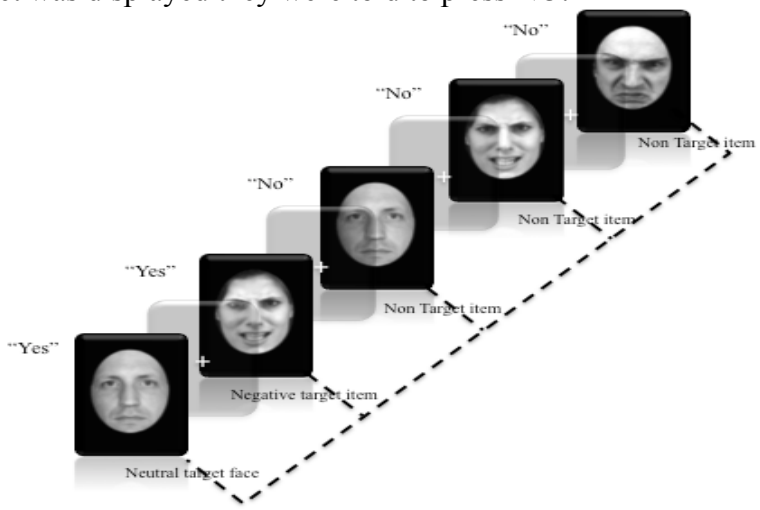

Figure 2. Illustration of the 2-back task. There are two target faces presented at the bottom of the sequence while the first three are of item type non-target faces.

Each face was presented for a period of 1000 ms with response threshold set at 1200 ms, between each face an Inter Trial Interval was set at 500 ms (Fig. 2). A trial run was completed of 20 runs along careful instructions how to complete the task and that the aim of the study was not to identify the emotion expressed, but the target faces. There were four blocks with a total of 576 trials, with three pauses as to prevent fatigue effects. 144 different faces were used, 72 were female and 72 were male. All faces appeared four times in the task, twice as target and twice as non-target. The faces were sampled from four databases, NIM-STIM (Tottenham et al., 2009), AR Face Database (Martinez & Benavente, 1998), Radbound face database (Langner et al., 2010) and The Averaged Karolinska Directed Emotional Faces (Lundqvist & Litton, 1998). All faces were viewed from the front with standardised colour, size and position. All faces were surrounded by black colour and possible confounding contextual variables removed. All faces were divided into three emotional conditions, with negatively angry, positively happy and neutral emotional expressions. In the negative category angry expressions were used and for the positive category, happy faces were used. A previous study using the same paradigm rated negative, positive and neutral expressions as different on valence dimension, and showed that negative and positive expressions were rated as high on arousal compared to neutral faces (Stiernströmer & Johansson, 2013).

Behavioural ratings. Participants´ behaviour during the experiment was recorded using a Logitech C525 HD web camera and saved for post hoc rating of behaviour. Three graduate students at Lund University carried out the behavioural ratings. They were instructed to rate emotional behaviour on valence and arousal dimensions. Both measures were rated on a scale ranging from 1 to 9, where 9 was considered aroused or positive and 1 un-aroused and negative. From the recorded videos a two-minute sequence from the beginning of each session of participants from G2 and G3 was chosen, rendering fifty-six videos and approximate two hours of material. Videos were randomised as to avoid order effects.

Expressive Suppression implementation. Following the WM task, participants in G3 were asked to provide information on how they implemented the instruction to suppress behaviour and not show emotions for the camera. In order to compare manipulation results of ES with other studies, a similar as possible translation of previously used instruction to implement ES was used, *"You will be asked to push down any behaviour related to the discomfort of having your hand in cold water. Even if you experience it as uncomfortable to have your hand in water you are asked not to show this, thus making sure that no outsiders could identify what you are feeling"* (Gross, 1998a).

Procedure

Participants were placed in groups (G1, warm water, G2, cold water and G3 cold water and ES) decided by a randomisation procedure conducted using the EDGAR tool (Brown, 2005). In order to control for confounding variables in the surrounding a complete block design was used. Participants were asked to fill in a consent form that explained what was expected and how to conduct the task and that they would be recorded using a web camera placed on top of the computer screen and that their facial expressions would be analysed post hoc. All instructions were kept similar across groups except for the instruction to implement ES for G3. Instructions related to the 2-back task were presented on the computer screen and the trial run was completed. Participants were told to press the enter button to proceed with the test, and when they did, put their hand in the water. All were instructed to keep their hand in the water during the entire test and that they themselves decided the amount of time spent on the pause between each block. Having completed the 2-back task they were asked to rate their experience using the SAM-scale and G3 were asked to answer the question related to ES.

Data analysis

Performance measures were collected and standardised in regard to discrimination accuracy index using the "too high threshold model" (Snodgrass & Corwin, 1988). When using a WM recognition task as a measure of capacity and as performance measure differentiating between groups, a model to correct for "lucky guessing" is needed. The model accounts for the probability of answering yes or no to an old or a new item and is hence a term of recognition. Therefore, discrimination (Pr) is seen as a measure of answering yes to an item corrected for "lucky guessing", and is a measure of higher capacity indicating the ability to discriminate between target and non-target. The response bias (Br) measure is hence a mirror effect of the Pr measure and determines how prone a participant is to answer yes or no when uncertain, this is seen as the ability to react in a conservative or liberal manner and is determined by the numbers 0.5 and -0.5. Reactions to target above 0,5 are seen as a liberal response bias and below -0,5 as conservative response bias and all results in between are regarded as neutral. Discrimination and response bias are calculated using the formula where H = hit, Fa = false alarm. $(P_r) = H\text{-}Fa$ and $(B_r) = Fa/[1-(H-Fa)]$ (Snodgrass & Corwin, 1988).

Analysing the material was done using IBM SPSS 20. Univariate analysis of variance (ANOVA) was used to analyse between group differences. Post hoc test used Bonferroni

correction for multiple comparisons. T-tests were used to analyse subjective measures of valence and arousal and the post hoc behavioural measures. Behavioural measures were validated using Pearson´s r.

In order to account for different sub-strategies used to suppress behaviour an analysis based on the frequency of mentioned strategies was done and put into categories. The analysis was conducted in accordance with the constant comparative method as an inductive method working with qualitative data (Maykut & Morehouse, 1994). The method assumes that no previous hypothesis exists that is to be confirmed or discarded, but generates categories that post hoc are compared with existing literature. The method builds on a step-wise analysis where units are analysed and put into categories. Those categories are constantly compared to the material across categories as a process. Results were compared to the literature and presented using units of quotes as empirical evidence (Widerberg, 2002).

In this study, between-group comparisons were executed using a 2-back task as a measure of WM capacity to discriminate between conditions, having a hand in warm water (G1) cold water (G2) and cold water and implementing ES (G3). Measures are obtained as manipulation check for the CPT, implementing of ES and the experienced valence and arousal.

Results

Subjective measures

Using t-tests to discriminate between groups on valence and arousal dimension, subjective measures revealed that, G1 (warm water) and G2 (cold water) differed significantly in regard to level of experienced valence $t(54) = 2.55$, $p = .01$. Notable is that there was a trend $t(54) = -1.53$, $p = .13$, on the dimension of valence between G2 and G3, indicating that being part of the G3 was experienced as more positive than being in G2. There were no differences in regard to subjective measures of arousal, $t(54) = -1.05$, $p = .30$, between G1 and G2 and $t(54) = 0.04$, $p = 97$, between G2 and G3. Neither were there any significant differences between G1 and G3, $t(54) = -1.11$, $p = .27$. For means and standard deviations see Table 2.

Observer ratings

The objective rating of behaviour between G2 and G3, both arousal and valence measures broke the limit of 1.0/-1.0 on skewness, they were transformed using the

logarithmic transformation. There was a trend indicating that G2 was rated as more aroused $t(52) = 1.59$, $p=.12$, than G3. No significant difference was found in regard to valence, $t(52) = 0.14$, $p=.90$. All objective measures were correlated using Pearson´s r to test for inter-rater reliability. Results are displayed in Table 3.

Table 2

Means and Standard Deviations from subjective and objective measures of arousal and valence, n.a. indicate that results are not available.

	M			SD		
	G1	G2	G3	G1	G2	G3
Subjective arousal	29.07	31.21	31.14	8.06	7.28	5.69
Subjective valence	29.5	24.61	27.21	7.38	6.94	5.74
Objective arousal	n.a.	2.73	2.6	n.a.	0.22	0.31
Objective valence	n.a.	2.67	2.66	n.a.	0.26	0.20

Table 3

Inter-rater reliability for objective ratings of valence and arousal.

	A 1	A2	A3	V1	V2	V3
Arousal 1	1					
A2	.19	1				
A3	.57*	.43*	1			
Valence 1				1		
V2				.68*	1	
V3				.56*	.62*	1

*Correlation is significant at the 0.01 level (2-tailed).

Discrimination and Response bias measures

The initial analysis using ANOVA revealed no significant omnibus effect between groups on Pr negative facial expressions, $F(2, 81) = 1.75$, $p=.18$, $\eta^2_p= .041$. G1 and G2 did not differ significantly $p=.28$, and G2 did not differ significantly from G3 $p=.40$, neither were there any significant difference between G1 and G3, $p=1.0$. For Pr measures positive facial expressions, groups did not differ significantly, $F(2, 81) = 1.23$, $p=.30$. There was no

difference between groups on neutral facial expressions, $F(2, 81) = 0.44$, $p=.65$. In clarification of direction, see Table 4.

Table 4

Mean and Standard Deviations for group differences on discrimination accuracy (Pr).

	M			SD		
	G1	G2	G3	G1	G2	G3
Pr negative	1.42	1.31	1.39	0.18	0.29	0.24
Pr positive	1.35	1.25	1.34	0.19	0.29	0.25
Pr neutral	1.33	1.27	1.32	0.21	0.23	0.24

Using ANOVA, there was no overall effect on Br negative facial expressions, $F(2, 81) = 0.10$, $p=.90$. Neither did groups differ significantly in regard to Br positive measures, $F(2, 81) = 0.63$, $p=.53$. Br for neutral facial expressions between groups did not differ significantly, $F(2, 81) = 0.47$, $p=.63$. See Table 5 for means and standard deviations.

Table 5

Means and standard deviations for Response bias (Br) measures between groups.

	M			SD		
	G1	G2	G3	G1	G2	G3
Br negative	1.08	0.53	0.55	8.03	3.35	2.41
Br positive	1.5	1.41	0.26	6.59	2.85	3.52
Br neutral	1.33	1.27	1.32	0.21	0.23	0.24

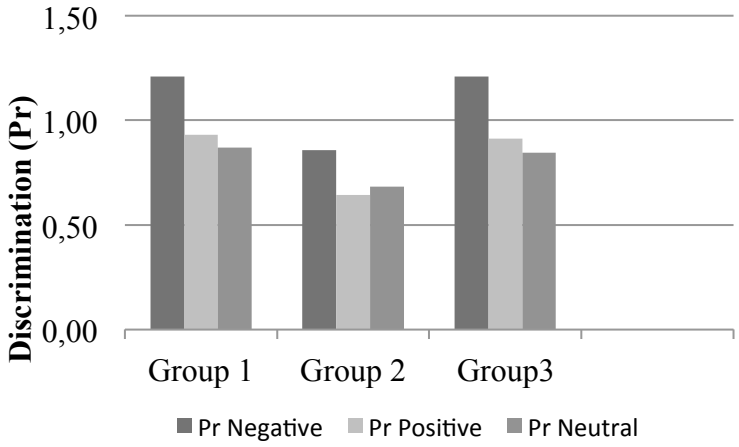

Figure 3. This diagram displays between group differences in accuracy measures Pr, they were not significant.

Strategies for implementing Expressive Suppression

To investigate how ES participants in G3 implemented the instruction not to display emotional behaviour they were asked to write about how they implemented the instructions. Independently of each other twelve participants indicated using an attention deployment strategy of distraction. Participants described their strategy as, *"Tried to concentrate as much as possible on the screen to forget the hand"*. A few participants also used an attention deployment strategy more closely related to acceptance, venting and relaxing, where they described how they used their breathing as a tool to inhibit activation from the CPT. Participants described it as, *"Breath calmly and focused on not using facial muscles".* Also indicated independently of each other, some participants reported using a situation modification strategy of problem solving. This was indicated with comments as, *"Focus on pushing the buttons fast so it would be over sooner"*. Some participants also described how it got easier to complete the test over time as the water warmed and the hand habituated to the situation of the CPT, i.e. describing it as, *"After a while it felt as if I did not notice the hand in the water"*. In addition, approximately one third did not understand or answered irrelevantly as indicated by their answers such as *"cleansed my fist hard"* or *"got frustrated from missing so many faces"*.

Discussion

The aim of this study was to compare groups on performance measures standardised into accuracy Pr and response bias Br measures across conditions, hand in warm water (G1), cold water (G2) and cold water and implementing ES (G3). Subjective and objective measures were used to differentiate between each condition where G2 and G3 were hypothesised to experience the task as less positive than G1 and where G3 were to experience more arousal than G2. G2 was also hypothesised to express more aroused behaviour compared to G3. The main findings were small but non-significant differences between G1 and G2 and G2 and G3 on performance measures Pr. G2 in general performed worse than other groups and also rated their experience lower on the valence scale.

Subjective experience of the CPT

Predicted results from the subjective measures were that groups having their hand in cold water would differ in experienced valence from having their hand in warm water and that G3 would experience more arousal compared to other groups. Results from subjective

measures using the SAM-scale indicate a successful induction of valence where G2 (with their hand in cold water) experienced the CPT as less positive than G1 (with their hand in warm water). Further results using the SAM-scale suggest a trend where G3 experienced more positive valence than G2, while being subjected to the CPT and asked to implement ES. A successful induction of valence for G2 makes it interesting to discuss why G3 experienced more positive valence than G2 even though there was a lack of significance. The explanation for this difference could be found in the implementation of ES as a strategy, or rather that participants in G3 were told to implement a specific strategy giving them an incentive to focus extra hard or to use an ER strategy at all, meaning that they experienced the task as more positive. The difference in experienced valence is hence probably caused by expectancy put on participants in G3 leading to extra focus on not to show emotional behaviour and in turn enhancing the focus on other parts of the overall task.

No difference was found on subjective measures of arousal between G3 and G2 as hypothesised. This problem could be discussed in terms of bottom-up and top-down generated emotions. It is possible that the difference in regulating emotion can be accountable for some of the current findings, where a lack of arousal was observed for G3. This result adding to the importance of closely conceptualising what an emotion is to be considered and how it is operationalised in every study (McRae et al., 2012). The mix of emotion generation to be regulated in this study both in terms of the CPT generating a potency of activation through a mild pain reaction and an activation from facial expression was used because of the highly demanding 2-back task where an emotional response might not have been provoked by mere angry faces, thus demanding a higher potency from the CPT. The lack of higher arousal for G3 can thus be a result of the highly demanding 2-back task, the complex situation and as we conclude further down, the use of other ER strategies other than ES to down regulate the emotional response shown here as a lack of experienced arousal.

Objective ratings of expressive behaviour

As a manipulation check for G3 implementing ES, G2 was hypothesised to express more emotional behaviour. Results showed that G3 was rated as displaying less aroused behaviour than G2, however, not a significant difference as rated by observers. Previous studies have measured physiological activation when implementing ES and concluded that the internal change in physiology does not necessarily lead to a difference in behaviour (Gross & Levenson, 1993). Meaning that the lack of difference between groups in this comparison may

be explained in other ways. One such explanation can come from questioning the usefulness and oversimplification of ER (Cole, Martin and Dennis, 2004). Especially one argument becomes important in regard to the current study. The lack of ecological validity in a study where an artificial and laboratory environment sets the standard for a phenomenon understood and explained in a social situation interacting with other humans. The influence of such limitations on this study can partially be explained in a reciprocal manner. It is possible that the provoked artificial situation used here measures a different construct than ES in a social situation, hence questions what ES really is to be seen as. Some strength also comes from the same source of limitation. Though, to study and find group differences disregarding low ecological validity might be argued to easier generalise into a social situation with "real" emotions to regulate. The argument can thus be that if differences can be found within the limited scope of the laboratory, real life differences are more probable. Even so, in this specific study contextual cues might be the mediator of ES, given the complexity of the task and requirements put on participants, it would be hard to separate what limited and what enhanced the stress put on participants provoking an emotion (Aldao, 2013; Campos et al., 2011). Especially for what real benefit and prerequisite did participants in G3 have contrary to other groups of hiding their emotional expression? This might be seen as questioning the validity of the ES concept and hence questions what observers were rating. The low inter-rater reliability also adds to this conclusion and given that the constructs validity cannot exceed the measured reliability, this is a plausible explanation.

Accuracy measures and Expressive suppression

Performance measures were hypothesised to differ between groups where G3 were to perform worse then G1 and G2. In regard to results from the 2-back task, this study shows that groups did not differ significantly on Pr measures, suggesting no trade off on WM capacity when trying to implement ES (Fig. 3). Furthermore, there was no effect on Br measures between groups, suggesting that groups did not differ in making memory errors. The zeitgeist in the current field of ER and WM is that negative valence impairs WM (Banich et al., 2009; Gotoh, Kikuchi & Olofsson, 2010). This study lends some support to theory stipulating that negative valence is detrimental, because of a significant difference in regard to valence where G2 experienced more negative valence than G1. This suggesting that there would be a difference in regard to WM capacity. The difference was only partially supported though G2 performed worse than G1 on the task, there was no significance supporting any conclusions. The explanation found in the literature is in line with the current study where the

CPT generates a high level of negative valence that becomes effortful and detrimental, stealing attention from WM and thus generating worse results (Banich et al., 2009). However, the CPT did not have the same influence on G3 where they performed equally to G1 and better than G2. Even though, this difference was not significant it suggests an enhancing effect on WM for individuals implementing ES contrary to G2 who only had a CPT to worry about. This is interesting, since such a finding might suggest a non-linear relationship between negative valence states, higher level of arousal and WM with ES as a moderator. A significant effect between G2 and G3 might be very interesting, though such a finding would directly contradict existing theory in regard to ES as detrimental and instead support memory literature suggesting that arousal has an enhancing effect on memory, especially in terms of source memory binding (Bergmann et al., 2012; Levens & Phelps, 2008). It is important to note that no conclusions can be drawn from this study due to the lack of sufficient support for these results. The interaction between emotions, WM and ES is more complicated than this study can incorporate and this particular interaction calls for a continuation and interesting questions and hypotheses can arise from these results. The non-linear interaction between ES and WM is thus a contribution to the field as hypothetical, possibly providing a better reference of explanation in future studies.

Qualitative measures

The question of how G3 implemented instructions suggests that the non-significant result in behaviour measures might come from the usage of antecedent focus strategies rather than the response-focused strategy of ES. This is evident from the answers provided by participants in G3 that describe their implementation of ES that is interpreted as strategies belonging to the antecedent focused part of Gross´s process model of ER. Answers such as *"Tried to concentrate as much as possible on the screen to forget the hand"* closely resemble a strategy of distraction and hence provides an explanation of why there was no difference in experienced arousal between G2 and G3 as hypothesised. The question designed for explaining sub-strategies of ES, instead question the implementation of ES and in turn questions what ES is to be seen as, emphasising the need for a better conceptualisation of ES. Since the operationalisation of the ES concept used in this study is designed to resemble those from previous studies, the suggestion is that there is a conceptual problem rather than a problem with the specific operationalisation or implementation used in this study. One possible explanation can be found in previous studies that discuss the importance of context and ER in general, (e.g. Aldao, 2013; Campos et al., 2004; & Campos et al., 2011). Where

contextual influences are important to incorporate, different ER strategies are suggested as moderators between the social context and strategies of maladaptive regulation and context is hence a confounding variable in this study, possibly explaining the usage of antecedent focused strategies rather than response-focused strategy of ES. It is also possible that participants´ failure to describe ES puts focus on what ES is? Previous studies examined in the introduction (Richards and Gross, 2000) argue that ES impairs memory performance via self-monitoring that is supposedly effortful. Results from memory performance measures in this study do not support such a conclusion. The argument here is instead that the use of ES as a strategy of down regulating emotional responses is dependent on context and situation and hence must be described in detrimental terms that can account for this multifaceted concept of ES instead of concluding that it always predicts worse memory performance.

Summary

To summarise the results, the lack of significance in regard to performance measures between groups and across conditions makes conclusions abundant. However, the observed differences and trends in regard to subjective valence together with lack of difference on performance measures support the theory that negative valence does not necessarily have to be detrimental in memory binding, and that it might depend on the observed stimuli. The existing theory stipulates that ES should steal cognitive capacity engaged in a self-evaluative process when implementing ES, instead of having an enhancing effect as this study shows, this calls for a continuation where ES possibly needs to be re-evaluated and a clearer and more concise conceptualisation is needed if theory is to stipulate that ES is detrimental and a worse strategy to regulate emotions.

Limitations and future directions

This study acknowledges limitations and the lack of ruling out coincidence as influence on manipulations. While results are not in line with our predictions, we did expect to find a difference on memory performance between groups, we failed to draw conclusions from the lack of difference due to non-significant results.

In a process model, emotion is seen as a trajectory always present but to a lesser or greater extent for every individual (Gross, 1998a; 1998b). The attrition of potency for G3 in terms of missing subjective arousal could be caused by the use of antecedent focused strategies instead of implementing ES. There is also a possibility that some of the “missing”

emotional behaviour for G2 can be accredited to the high demanding WM task, which could have been misinterpreted by observers (even though instructed to discard such indications). This might explain the low reliability for objective measures and hence questions the validity of the concept and our operationalisation.

This study used no physiological measures as indication of successful implementation of ES but relied entirely on the behavioural and subjective measures obtained and took the small difference as an indication of a partially successful implementation. This assumption of implementation of physiological activation without any physiological measures is possible due to other studies documenting the co-variation of the different dimensions of emotion (valence and arousal) with physiological measures (Bernat et al., 2011). The problem with such control measures instead of using physiological measures in this study is due to the small differences that are expected between groups. There are always weaknesses when studying intrapersonal phenomena such as WM, where every individual performs to a varying degree and generalising these results to group level as this study tries to do. The possibility is that captured in the test is a high variability within each sample, leading to small differences on a group level. It does not mean that there are no group differences due to the manipulation, but that the low power inherent in this kind of study can be held accountable for the small differences that are too weak to generate a significant difference within standard requirements.

Many studies reviewed so far question or emphasise the importance for future studies to closely examine ecological validity in regard to ER, the setting and what groups are included. Such a need was emphasised in the beginning of the process model (Gross & Levenson, 1993) where implementation regarding up- or down regulation of emotion was designed to closely resemble real life situations. The problem of ecological validity expands beyond the scoop of how we conceptualise within the field of ER and a need for more realistic settings is required. Studies in the future should therefore focus on the importance of context and culture when studying emotion in general and ER in particular. One suggested way to do this is to either expand the concepts as to explain social situations or find a way to bring social situations into the laboratory, as has been tried before (Goldstein et al., 2012). This emphasises a future need for a clearer conceptualisation where ES is studied on different levels and with different paradigms to support a more validated and robust theoretical model.

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