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Do generation and regulation of emotions interact? Examination of their relationships in young adults

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Abstract Emotions can be generated in response to inherently emotional perceptual properties of a stimulus ('bottom up') and in response to cognitive interpretations of an event ('top down'). Similarly, emotion regulation (ER) strategies may deploy bottom-up or top-down processes, however the specific nature of these processes remains unclear. In this study we sought to replicate and extend previous studies that have investigated the interaction between ER and emotion generation. Specifically, we examined the relationship between both methods of emotion generation and ER in a sample of 75 undergraduate students who completed self-report questionnaires and a behavioral task of ER. We attempted to extend previous research by testing whether the positive effect of cognitive reappraisal on top-down generated emotions was specific to reappraisal or true of multiple ER strategies. Overall there was a main effect of generation such that top-down generated emotion was better regulated by cognitive reappraisal, expressive suppression, and appraisal strategies. We also found a main effect of ER such that cognitive reappraisal was perceived as the most successful ER strategy. We argue that ER is a state-dependent process that includes dynamic cycles between emotion generation and regulation processes. We further discuss expressive suppression as a top-down emotion regulation strategy in the context of our study despite debated literature.

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Introduction

Emotion regulation strategies

Emotion regulation (ER) involves a diverse set of control processes that work together in the form of strategies aimed at manipulating when, where, and how we experience and express our emotions (Gross and Thompson 2007). As proposed by Gross (1998), there are at least two commonly used emotion regulation strategies. The first, *expressive suppression*, is an ER strategy that focuses on suppressing the outward expressions of emotion, albeit with little or no change in the ongoing internal emotion experience (Gross 2002). The second, *cognitive reappraisal*, involves challenging how an individual thinks about a situation as a way of decreasing its emotional impact, the aim of which is to decrease and qualitatively change both the experience and the behavioral expression of emotion.

The unique deployment of cognitive reappraisal and expressive suppression have different consequences for affective, cognitive, and social functioning (Gross and Thompson 2007). Cognitive reappraisal as an 'antecedent' strategy occurs early on in the emotion generation process, before an emotional response has fully arisen (Ochsner and Gross 2005). It involves the early selection and implementation of an ER strategy without the need for sustained effort over time. Long-term use of cognitive reappraisal is associated with enhanced control of emotion, interpersonal functioning, and psychological well-being (Gross and John 2003). On the other hand,

expressive suppression is a 'response focused' strategy that occurs late in the process of emotion generation, once an emotional response has fully arisen, producing decreased expressive behavior. While it may be adaptive in the short term, frequent use of this strategy has been found to result in diminished control of emotion, interpersonal functioning, and well-being (Gross and John 2003).

Modes of emotion generation

An important consideration that has not been fully explored in current research is how the processes underlying the generation of emotions impact subsequent ER success. Emotions can be generated primarily from the 'bottom up' in response to inherently emotional perceptual properties of a stimulus (e.g., a spider phobic seeing a spider) or 'top down' in response to cognitive interpretations of an event (e.g., interpreting an ex-partner's neutral behavior as distant and cold). Although everyday emotions involve a blending or some combination of bottom-up and top-down processing of encounters (Lindquist and Feldman-Barrett 2012), at any given time, emotions can generally be characterized by relatively stronger bottom-up or top-down generation. It is speculated that methods of emotion generation engage different psychological processes and neural systems (e.g., Ochsner et al. 2009) that are likewise implicated in some types of ER (McRae et al. 2012). Bottom-up emotion generation reliably elicits activity from the amygdala but is typically thought to occur outside of conscious awareness (Phelps and LeDoux 2005; Zald 2003). Top-down emotion generation also elicits activity in the amygdala, in addition to activation of the dorsomedial prefrontal cortex (PFC), the latter of which is thought to represent high-level self-relevant appraisals (e.g., Uchida et al. 2015), particularly when accessible to conscious awareness (Ochsner et al. 2009). Recently it has been suggested that these two processes of emotion generation (i.e., bottom-up and top-down) represent emotions using separable psychological processes and neural systems, which may make them differentially malleable by later ER (Otto et al. 2014). Further, the similarity in structures implicated in emotion generation and ER suggests that a core neural dynamic may underlie how these systems may interact to support successful regulation. The reliance on similar neural circuitry implies that the line separating emotion generation and regulation cannot be defined in simple anatomical terms. Instead, various brain systems may perform a role in supporting successful regulation depending on the context and the overlap between these processes.

The association between emotion generation and regulation

It is speculated that the interaction between emotion generation and the specific type of ER strategy employed will ultimately influence the success of efforts towards ER. For instance, top-down emotion generation involves bringing relevant aspects of the emotional appraisal to the forefront of attention. This activated representation may make these appraisals more accessible and amenable to efforts to manipulate or change them, as is done during cognitive reappraisal, (i.e., top-down regulation) (Ochsner and Gross 2005, 2008). In the case of bottom-up emotion generation, emotional information is often automatically elicited by physical or perceptual properties of the stimulus, and appraisals are not necessarily brought into focal attention or conscious awareness. Using a top-down ER strategy on a bottom-up generated emotion would require that the negative stimulus be brought back into one's active processing and conscious attention, thus maintaining a negative emotion that would otherwise be removed. This may be more effortful and require greater cognitive resources and as a result may have taxing consequences on ER. Thus it may be more adaptive to use a bottom-up strategy, which focuses on down-regulating the expression of emotion elicited, and requires lower-order, more automatic interpretations and cognitions. Therefore, it is possible that when emotion generation and subsequent regulation 'match' one another, the common underlying neural networks that these two emotion processes are hypothesized to share become activated and available to better support the ultimate success of regulation efforts.

To the extent of our knowledge, there have only been two published studies that have directly examined the relationship between emotion generation and ER. McRae et al. (2012) demonstrated that cognitive reappraisal is more effective in decreasing negative affect when emotion is generated in a top-down, versus bottom-up, manner. Results of this study indicate that concordance between generation and regulation facilitates regulation and when this concordance is not present, it may actually have counterproductive effects, increasing negative affect. Otto et al. (2014) showed support for these findings and provided novel evidence for overlapping neural processes between top-down ER and emotions that were generated in a top-down fashion. This emerging research is important because, until recently, there has been a tendency to view ER as a relatively homogenous construct, which may have limited our understanding of the complexity and multifaceted nature of ER, as well as is interaction with the mode of emotion generation. Furthermore, the few studies that have examined this relationship

have focused on cognitive reappraisal to the exclusion of other ER strategies, including expressive suppression.

Aims of the present study

In the current study, we sought to replicate and extend previous findings (McRae et al. 2012; Otto et al. 2014), by adding an expressive suppression condition (a common comparison condition for reappraisal), to test whether the facilitative effect of cognitive reappraisal on top-down generated emotions is specific to cognitive reappraisal, or true of multiple ER strategies. Our primary aim was to determine whether the way that an emotion is generated influences the impact of subsequent ER including cognitive reappraisal, expressive suppression, and appraisal. As mentioned above, unique to the current study was the inclusion of expressive suppression, in addition to the more traditionally studied cognitive reappraisal. Appraisal was also included as this condition is more representative of one's 'natural' emotional response system.

As our central hypothesis, we expected there to be a significant interaction between emotion generation and ER strategy with greater perceptions of ER success being associated with an association between cognitive reappraisal and top-down generated emotions. This would be consistent with previous studies (McRae et al. 2012; Otto et al. 2014). We chose to examine these questions within the context of a sample of young adults who are in a developmental period when ER processes are reaching maturation (Spear 2000), hoping that our hypothesized effect would be readily observed in this sample.

Methods

Participants

A total of 75 undergraduate students (77.3% females) participated in this study. All participants were undergraduates at the University of Victoria, between the ages of 19 and 25, who had normal or corrected-to-normal vision and could speak and understand English (needed for testing). Participants were recruited via posters and flyers that were circulated throughout the campus and through the research in psychology participant pool. On average, participants were 20.78 years old (SD = 1.7, range 19–25 years old), and had a mean of years of education of 13.81 (SD = 1.07, range 12–16 years). The ethnic composition of this sample included 2.7% Afro-Canadian, 10.7% Asian, 77.3% Caucasian, 4% Indian and 5.3% other.

Measures

Emotion regulation paradigm

For a comprehensive description of both the task training procedures and the ER task, we refer readers to Vanderhasselt et al. (2013). In brief, participants were shown a series of aversive pictures from the International Affective Picture System (IAPS; Lang et al. 1997) intended to generate temporary negative emotions[1]. The stimulus set has been shown to have mean arousal values >6 and mean valence ratings <4 based on normative ratings from a previous study (Vanderhasselt et al. 2013). We modified the task by also using emotionally evocative linguistic stimuli that have been found effective in other studies (e.g., negative sentences such as "Her son is in the burning building" were used from McRae et al. 2012). As such, linguistic stimuli in this study were considered triggers for top-down emotion generation, whereas pictures were triggers for bottom-up emotion generation. The stimulus set consisted of 45 negative pictures from the IAPS and 45 negative sentences. Each stimulus was shown only once for each participant. Although we acknowledge that the current literature remains equivocal in terms of clearly identifying top-down and bottom-up stimuli, our study was designed as a partial replication of findings from previously published studies in this area, using the same stimuli (McRae et al. 2012; Vanderhasselt et al. 2013).

Rather than allowing their own preference or 'default' ER strategy, participants were directly instructed by the researcher to 'suppress', 'reappraise' or 'appraise' their emotions in response to aversive stimuli. Participants provided a relative rating of their negative affect by answering the question, "How successfully were you able to reappraise/suppress/appraise your negative feelings elicited by the picture/sentence?" For the purpose of this study we focused on cognitive reappraisal and expressive suppression. A third condition, appraisal, was used as a break for participants to "do nothing" and naturally respond to the stimuli presented on the screen, thereby serving as a control condition as has been employed in other research (Vanderhasselt et al. 2013). Specifically, in the appraise condition, participants were instructed to respond naturally to the aversive stimuli and to not apply any explicit ER strategy. The success rating is indicative

[1] IAPS Picture Numbers used were as follows: 1022, 1120, 9252, 8230, 9423, 6560, 9910, 9181, 3051, 9911, 6350, 6825, 6313, 6230, 9421, 1310, 6370, 1304, 6211, 6312, 1070, 6213, 6550, 1525, 2811, 9050, 9921, 6834, 1205, 8485, 6212, 9254, 1050, 9400 9420, 9571, 6250, 6021, 6570, 2683, 6200, 1201, 9635, 1052, 9185 jpgs.

Table 1 Descriptive for perceived emotion regulation success rating

Perceived emotion regulation success rating	Mean (SD)	Range
Reappraisal sentences	3.35 (0.47)	2.1–4.0
Reappraisal pictures	2.98 (0.54)	1.9–4.0
Suppression sentences	3.28 (0.48)	2.1–4.0
Suppression pictures	2.93 (0.56)	2.0–4.0
Appraisal sentences	3.10 (0.56)	1.6–4.0
Appraisal pictures	2.75 (0.61)	1.7–4.0

of an evaluation of 'relative negative affect' based on the application of an explicit ER strategy. Descriptive statistics associated with perceived ER success rating (i.e., a subjective impression of successful ER rather than the intensity of experienced emotion) can be found in Table 1.

All stimuli were presented on an Acer Aspire 5741 laptop and were displayed on a 15.6-inch screen by means of E-Prime 2.0 software (Schneider et al. 2002). Testing was conducted in a small quiet testing room, free of any distractions (e.g., windows or other visual distractions).

Task

During the ER paradigm (see Fig. 1) participants were cued to suppress, reappraise, and appraise a series of 90 randomly intermixed trials in three blocks. The order of the instructions was randomized between blocks and for each participant. Each trial started with a fixation cross (0–1.5 s, jitter in steps of 500 ms) followed by a cue word (suppress, reappraise or appraise). This cue word appeared centrally on the screen for 3 s, after which a blank screen was presented (1–9 s, jitter in steps of 500 ms and mean duration of 4.5 ms). This cue-offset time enabled participants to prepare for the instructed ER strategy. Subsequently, a negative, high arousing image or sentence appeared centrally for 10 s. Although the image or sentence remained on the screen, participants performed the ER or appraisal specified by the prior instructional cue.

Task training

To standardize how participants applied the different instructions (appraise/suppress/reappraise), they were trained for ±20 min beforehand. The training instructions used in this study are those employed in previous research conducted by Vanderhasselt et al. (2013). The number of practice trials differed between participants depending on when they achieved a minimum level of understanding or proficiency in suppression, reappraisal, and appraisal. Participants were also trained to enhance preparatory control supporting the specific strategy they were instructed to employ. During the preparation phase, participants were told that an unpleasant, affect-laden stimulus (picture or sentence) would appear in all trials. For the cognitive reappraisal and expressive suppression instruction participants were instructed to down-regulate and maintain control over the expression of their feelings respectively.

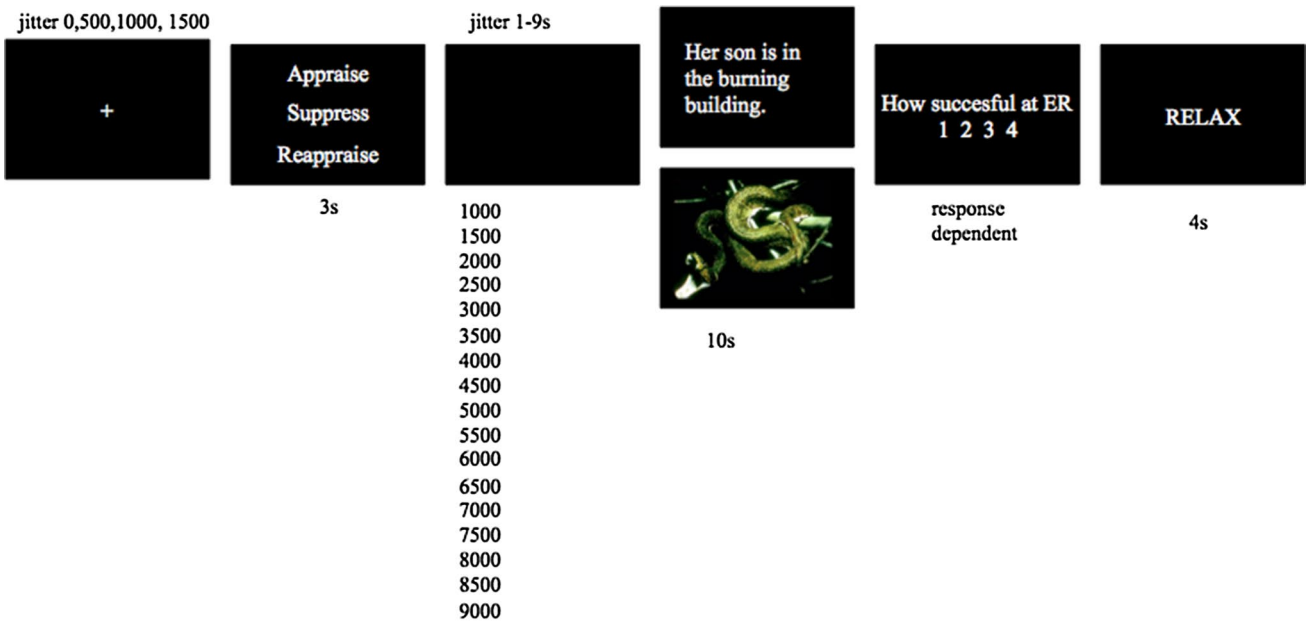

Fig. 1 Emotion regulation task refined from Vanderhasselt et al. (2013). 'Put on your poker face': neural systems supporting the anticipation for expressive suppression and cognitive reappraisal. *Social Cognitive and Affective Neuroscience*

During the practice phase, participants were asked to verbally state what they were thinking during the preparation (cue) and picture/sentence (target) phase. This way, the preparation and actual target phase was standardized across all participants. For all the stimuli, participants were told not to look away and to concentrate on the stimuli during the time it was projected on the computer screen.

Report of perceived ER success

Immediately subsequent to the presentation of every individual stimulus, participants were asked to report how successful they were in down-regulating negative affect based on the application of the explicit ER strategy to control their negative emotions. As mentioned above, participants were asked the following question after the presentation of each stimulus: "How successfully were you able to reappraise/suppress/appraise your negative feelings elicited by the picture/sentence?" Thus, perceived ER success was operationalized using a Likert scale that allowed them to rate how successful they were in regulating or appraising their negative emotions (1 = not at all to 4 = very good) following the presentation of each aversive stimulus. Successful ER was indexed as a mean rating of >3 on a Likert scale from 1 to 4, which suggests that participants were able to regulate their emotions elicited by the stimuli presented (i.e., ER success indexed by down regulation of negative emotion). The final index of perceived ER success was obtained by first summing the success rating for every individual stimulus, and then taking the average score (i.e., for cognitive reappraisal and expressive suppression separately). Successful cognitive reappraisal implies that the participants were able to down-regulate negative feelings, whereas successful expressive suppression implies that they were able to not show their feelings on an outward level. All together, the success rating is indicative of an evaluation of 'relative negative affect' based on the application of an explicit ER strategy. It is important to note that an attempt was made to obtain measures of momentary affect, however, given a corruption in the computer program this was not recorded correctly. Specifically, at the end of the ER paradigm, participants were asked to rate the arousal and valence for each of the stimuli. As such, the effects that are reported are dependent on participant's judgment of success rather than an objective rating of their momentary affect or expression. Finally, the word 'RELAX' appeared on the screen for 4 s, which allowed participants to relax until the presentation of the next trial.

Procedures

The Human Research Ethics Board at the University of Victoria approved the experimental protocol for this study. Participants provided informed consent and then were asked to fill out a record of participation, which required their name, date, and contact information. Subsequent to this, each participant was associated to a randomly assigned identification number in order to maintain confidentiality of further data collection.

This study consisted of one session lasting approximately 2 h. Participants were first asked to complete a demographic and life-stress questionnaire followed by the self-report scale of ER. Participants then began the training phase of the computerized ER task for approximately ±20 min. The number of practice trials differed between participants depending on when they achieved a minimum level of understanding or proficiency in suppression, reappraisal, and appraisal. After successfully completing the training phase, participants began the test phase of the ER task. In each phase of the test, instructions were displayed on the computer screen and the experimenter sat quietly outside of the testing room. When participants were finished the computerized testing they notified the experimenter and this marked the completion of the experiment.

Results

Interactions between emotion generation and regulation

Table 1 provides descriptive statistics for participants' subjective impression of successful ER as a function of regulation condition (i.e., cognitive reappraisal, expressive suppression, appraisal) and emotion generation condition (i.e., sentences, pictures). With the independent variables of generation (sentences and pictures) and regulation (cognitive reappraisal, expressive suppression, and appraisal), we conducted a 2×3 analysis of variance (ANOVA) to test the hypothesis that the way that an emotion is generated interacts with the ER strategy deployed to predict perceived ER success. Results indicated a non-significant interaction effect [$F(2, 449) = 0.041$, $p = .960$, partial $\eta^2 = 0.000$]. We did, however, observe a significant main effect of generation [$F(1, 449) = 49.54$, $p < 0.001$, partial $\eta^2 = 0.100$] such that top-down generated emotions (i.e., those elicited by negative sentences) were better regulated by each of cognitive reappraisal, expressive suppression, and appraisal compared to bottom-up generated emotions (i.e., those elicited by the presentation of negative images). We also found a main effect of regulation strategy [$F(2, 449) = 8.08$, $p = < 0.001$, partial $\eta^2 = 0.035$], such that participants were most successful at regulating their emotions using cognitive reappraisal.

Discussion

In the present study, we aimed to replicate and extend the emerging literature examining the interaction between emotion generation and ER on perceived ER success. Although our findings did not show an interaction effect between method of emotion generation and regulation, we found support for a main effect of emotion generation and a main effect of ER on individual's perceived success at regulating their emotions. Specifically, we found that top-down generated emotions (i.e., sentences) were better regulated by all three regulation strategies (i.e., cognitive reappraisal, expressive suppression, and appraisal) as opposed to bottom-up generated emotions (i.e., pictures). The specific success of cognitive reappraisal on top-down generated emotions (i.e., the main effect of ER) is consistent with findings from previous research (McRae et al. 2012; Otto et al. 2014) indicating that individuals are better able to cognitively reappraise emotions when triggered by more top-down stressors.

The main effect of emotion generation, however, was an unexpected finding—the fact that all three ER strategies (i.e., cognitive reappraisal, expressive suppression, and appraisal) better regulated top-down generated emotions more effectively than bottom-up emotions. This finding could be interpreted in several ways. First, it could indicate that top-down generated emotions are easier in general to regulate. Because they involve conscious cognitive elaboration including high-level self-relevant appraisals (e.g., Uchida et al. 2015), they are likely associated with more controlled processing, therefore happening on a slower time-scale and thus more amenable to subsequent regulation. This is in contrast to bottom-up generated emotions that are immediate and automatic and often thought to occur outside of conscious awareness (e.g., Goldin et al. 2008), which may place greater demands on the regulation system.

An alternative interpretation is that, although we conceived of expressive suppression as a bottom-up regulation strategy, it is possible that within the context of our study, it also functioned as a top-down strategy, and this is why it was successful in regulating top-down generated emotions. In fact, the literature indicates that bottom-up ER strategies are still incompletely understood and defined in the literature, and there is even debate over which ER strategies can be defined as a "bottom-up" (e.g., Chiesa et al. 2013). Moreover, the functionality of strategies such as expressive suppression may be dependent on the context. For example, Mauss et al. (2007) make the argument that adults with avoidant attachment styles may have learned in early life that expression of (negative) emotion is incompatible or ineffective with regards to goals related to one's caregivers (Shaver and Mikulincer 2007). Into adulthood, such individuals may then learn to routinely inhibit negative emotional impulses (Kobak et al. 1993; Mikulincer and Shaver 2003), a process which becomes automatized over time, and as such would represent a bottom-up ER strategy. Conversely, other literature suggests that use of expressive suppression involves activation of executive control areas including prefrontal cortex, which would suggest top-down control (Silvers et al. 2013). However, it is important to note that such studies are typically laboratory-based, experimental studies whereby participants are explicitly told how to regulate emotion, which would by definition infer the need for some degree of conscious control regardless of strategy type. That is, in the current study, by telling participants when to use expressive suppression, this may have inadvertently turned it into a top-down strategy, whereas in daily life it might occur more spontaneously and automatically as a bottom-up strategy. With this interpretation in mind, it is not surprising, then, that expressive suppression successfully regulated top-down generated emotion, and incidentally provides further support for understanding nuances in the interaction between generation and regulation.

Concerning the interaction between top-down generated emotion (i.e., sentences) and cognitive reappraisal, some researchers have speculated that this interaction is subsumed by cognitive and neural processes recruited simultaneously by both reappraisal and top-down generated emotions (Otto et al. 2014). Interestingly, researchers have drawn similarities between this hypothesized process overlap and a property of memory known as transfer-appropriate processing (TAP; Roediger et al. 1989). TAP rests on the notion that some types of cognitive performance, including memory, are state-dependent. Otto et al. (2014) recently extended this process-overlap framework to the context of emotions. They found that cognitive reappraisal and emotions that were generated from the top-down shared a specific core network (i.e., prefrontal, temporal, and cingulate regions), whereas there was no such overlap between cognitive reappraisal and emotions that were generated in a bottom-up fashion.

To our knowledge, the process overlap framework has not yet been extended to expressive suppression and research in this area is still very novel. The tendency to focus on cognitive reappraisal is perhaps unsurprising given the predominating role of cognitive models of emotion in the literature (Ochsner and Gross 2005), as well as the ubiquity of cognitive therapy for mood and anxiety disorders characterized by negative affect (Beck 2011). There is still great debate in current literature about whether expressive suppression can be viewed as a top-down or bottom-up ER strategy. If "bottom-up" implies automatic or outside of conscious awareness, then perhaps participants reflexively use this strategy in naturalistic environments;

however, in a lab setting the ecological validity likely is reduced. This could explain why we found a significant main effect of generation, whereby participants had the impression that top-down generated emotions were better regulated by both cognitive reappraisal and expressive suppression. As discussed previously, in the context of the current study there is a strong possibility that expressive suppression functioned more as a top-down ER strategy, given that participants were extensively trained and instructed to utilize this technique on command. Given that bottom-up regulation is largely an automatic process, by explicitly telling participants how to suppress their emotion may have caused this ER strategy to become more of a top-down cognitive technique. Our findings contribute to the extant literature on expressive suppression that appear to largely be in its infancy. It is still unclear as to whether expressive suppression can be viewed as a bottom-up or top-down strategy; however, our results shed light on the importance of considering context when understanding how ER strategies are functioning.

The processing of bottom-up stimuli is often unconscious and relatively automatic (Phelps and LeDoux 2005), and occurs with less frequency compared to top-down emotions. Our findings highlight the need to examine whether the process overlap framework does in fact extend to bottom-up methods of emotion generation and regulation. One possible factor that is hypothesized to contribute to bottom-up emotion generation and regulation is one's level of interoceptive awareness. Physical cues for emotion, cognition, and behavior may be central to facilitating bottom-up emotion processes, which are usually unconscious and relatively automatic as discussed above (Phelps and LeDoux 2005). Individual differences in interoceptive awareness may predict success in regulating bottom-up emotions. In fact, evidence-based treatments for specific anxiety disorders (e.g., phobias, trauma) typically include exposures (including interoceptive exposure), whereby instead of engaging in avoidance strategies individuals learn to tolerate intense emotions (Nacasch et al. 2015). While the majority of studies examining the process model focus on cognitive reappraisal and expressive suppression, few directly examine the "appraise" instruction, which may be closer to an exposure strategy and thus more effective in bottom-up regulation. Thus, future studies may benefit from directly examining the impact of pure appraisal in regulating bottom-up emotions.

Finally, the unexpected finding regarding greater difficulties regulating bottom-up generated emotion as opposed to top-down generated emotion (i.e., the main effect of generation) may be a function of the developmental characteristics of the participants in our study. Research indicates that the period from adolescence to young adulthood is marked by enhanced bottom-up emotional processing in subcortical regions, and consequently heightened emotional reactivity (Casey et al. 2008). This is coupled with the ongoing development of the PFC, which is thought to create an imbalance in emotion processes. Thus it seems reasonable that participants in this sample may have had more difficulty regulating bottom-up generated emotions given that emotions generated in a bottom-up manner are hyperactive during this stage of life. Moreover, this competition between enhanced activity in subcortical emotional processing systems and less mature top-down prefrontal systems may have also made participants in this sample more vulnerable to the effects of bottom-up generated emotions. Future studies should work to replicate these findings and extend them across different age groups and developmental periods to better understand the relationship between bottom-up emotion generation and regulation processes.

Overall, this study represented the initial foundations of work on this topic, which the authors are pursuing further, by incorporating an objective physiological measure (i.e., heart-rate variability) as an index of emotion regulation. This is not to discount the validity of individual's own first-person report of emotional experience. Mauss and Robinson (2009) conducted a comprehensive review of the extant literature on measures of emotions, acknowledged the multi-faceted and complex nature of emotional experience. The results of this review indicated that, across different response systems, evidence suggests that different measures of emotion reflect different dimensions rather than discrete states. Thus, the results of the present study add an important and initial piece to our ongoing understanding of emotional experience. Given that research indicates there is no "gold standard" of emotional responding, it is important for future research to continue to examine the unique variance contributed by self-reported emotional experience, behavioral task performance, and physiological responding as each provides different, unique sources of information about emotional experience, with no one source better or more valid than the other. It is hoped that in future work, we can examine the concordance and discordance between these different methods, which could provide useful information on other higher-order constructs such as, self-awareness and alexithymia.

Limitations and future directions

Despite the current contributions, some limitations should be addressed. First, our sample was fairly homogeneous in terms of age and educational background, which may limit the generalizability of the results.

Future studies would benefit from a more diverse sample, including young persons from contexts where there may be a greater range of psychopathology symptoms reported (e.g., mental health clinics), leading to greater variation in emotional experience. Additionally, the integration of biomarkers such as functional neuroimaging or heart-rate variability (e.g., Pu et al. 2010), not available in our study, may provide greater understanding of a proposed shared neural basis for matching systems. It is important to note that an attempt was made to obtain measures of emotional reactivity and self-reported affect during the ER paradigm, acknowledging that self-reported ER success is not equivalent to reported affect *per se*. However, given a corruption in the computer program we were not able to access or analyze this data. Thus, although it was not an oversight in the current study, future research should aim to account for emotional reactivity and self-reported momentary affect as a part of the ER paradigm (e.g., see Vanderhasselt et al. 2013). Lastly, we acknowledge that, in the context of our study, we did not include a naturalistic observation of the use of ER strategies nor the elicitation of emotion. Future work should focus on better empirically testing whether expressive suppression can be viewed as a bottom-up automatic process or a top-down ER strategy. Specifically telling participants that they have to expressively suppress their emotion in response to aversive sentences and images may bring what would be naturalistic and outside of conscious awareness to the forefront of their attention, making bottom-up ER become more of a top-down process, and might therefore explain why it also better regulated top-down generated emotion. We believe that it is fair to discuss this in terms of a limitation of our study and for future efforts to be geared toward more clearly understanding bottom-up ER strategies.

In summary, we found that overall we are better able at regulating top-down generated emotions (i.e., sentences). Further, we appear to be better at engaging in cognitive reappraisal to successfully regulate our emotions, compared to expressive suppression and appraisal (i.e., reacting naturally to a situation). Our findings, although not finding a main effect between emotion generation and regulation, does show that type of emotion regulation strategy and the way in which our emotions are generated are both unique and important pieces in understanding one's emotional experiences

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References

Beck, J. S. (2011). *Cognitive behavior therapy: Basics and beyond*. New York: Guilford Press.

Casey, B. J., Jones, R. M., & Hare, T. A. (2008). The adolescent brain. *Annals of the New York Academy of Sciences, 1124*(1), 111–126.

Chiesa, A., Serretti, A., & Jakobsen, J. C. (2013). Mindfulness: Top–down or bottom–up emotion regulation strategy? *Clinical Psychology Review, 33*(1), 82–96.

Goldin, P., McRae, K., Ramel, W., & Gross, J. J. (2008). The neural bases of emotion regulation: Reappraisal and suppression of negative emotion. *Biological Psychiatry, 63*, 577–586.

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology, 2*, 271–299.

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychopathology, 39*, 281–291.

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 3–24). New York: Guilford Press.

Gross, J.J, & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85*(2), 348–362.

Kobak, R. R., Cole, H. E., Ferenz-Gillies, R., Fleming, W. S., & Gamble, W. (1993). Attachment and emotion regulation during mother-teen problem solving: A control theory analysis. *Child Development*, 231–245.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). *International Affective Picture System (IAPS). (1997). Technical Manual and Affective Ratings. NIMH Center for the Study of Emotion and Attention*. Gainesville, FL: University of Florida.

Lindquist, K. A., & Barrett, L. F. (2012). A functional architecture of the human brain: Emerging insights from the science of emotion. *Trends in Cognitive Sciences, 16*(11), 533–540.

Mauss, I. B., Bunge, S. A., & Gross, J. J. (2007). Automatic emotion regulation. *Social and Personality Psychology Compass, 1*(1), 146–167.

Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition and Emotion, 23*(2), 209–237.

McRae, K., Misra, S., Prasad, K. A., Pereira, C. S., & Gross, J. J. (2012). Bottom-up and top-down emotion generation: Implications for emotion regulation. *Social Cognitive and Affective Neuroscience, 7*(3), 253–262.

Mikulincer, M., & Shaver, P. R. (2003). The attachment behavioral system in adulthood: Activation, psychodynamics, and interpersonal processes. *Advances in Experimental Social Psychology, 35*, 53–152.

Nacasch, N., Rachamim, L., & Foa, E. B. (2015). Prolonged exposure treatment. In M. P. Safir, H. S. Wallach & A. Rizzo (Eds.), *Future directions in post-traumatic stress disorder* (pp. 245–251). New York, NY: Springer.

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences, 9*, 242–249.

Ochsner, K. N., Ray, R. R., Hughes, B., McRae, K., Cooper, J. C., Weber, J., ... & Gross, J. J. et al. (2009). Bottom-up and top-down processes in emotion generation common and distinct neural mechanisms. *Psychological Science, 20*(11), 1322–1331.

Ochsner, K.N., & Gross, J. J. (2008). Cognitive emotion regulation: Insights from social cognitive and affective neuroscience. *Current Directions in Psychological Science, 17*(2), 153–158.

Otto, B., Misra, S., Prasad, A., & McRae, K. (2014). Functional overlap of top-down emotion regulation and generation: An fMRI study identifying common neural substrates between cognitive reappraisal and cognitively generated emotions. *Cognitive, Affective, & Behavioral Neuroscience, 14*(3), 923–938.

Phelps, E. A., & LeDoux, J. E. (2005). Contributions of the amygdala to emotion processing: From animal models to human behavior. *Neuron, 48*(2), 175–187.

Pu, J., Schmeichel, B. J., & Demaree, H. A. (2010). Cardiac vagal control predicts spontaneous regulation of negative emotional expression and subsequent cognitive performance. *Biological Psychology, 84*, 531–540.

Roediger, H. L., Weldon, M. S. III, Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger III & F. I. M. Craik (Eds.), Varieties of memory and consciousness: Essays in honor of Endel Tulving (pp. 3–41). Psychology Press, Hove

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime: User's guide*. Psychology Software Incorporated.

Shaver, P. R., & Mikulincer, M. (2007). Adult attachment strategies and the regulation of emotion. *Handbook of emotion regulation*, (pp. 446–465). New York: Guilford Press.

Silvers, J. A., Buhle, J. T., Ochsner, K. N., & Silvers, J. (2013). The neuroscience of emotion regulation: Basic mechanisms and their role in development, aging and psychopathology. *The Handbook of Cognitive Neuroscience, 1*, 52–78.

Spear, L. P. (2000). The adolescent brain and age-related behavioral manifestations. *Neuroscience & Biobehavioral Reviews, 24*(4), 417–463.

Uchida, M., Biederman, J., Gabrieli, J. D., Micco, J., de Los Angeles, C., Brown, A., & Whitfield-Gabrieli, S. (2015). Emotion regulation ability varies in relation to intrinsic functional brain architecture. *Social Cognitive and Affective Neuroscience, 10*(12), 1738–1748.

Vanderhasselt, M. A., Kühn, S., & De Raedt, R. (2013). 'Put on your poker face': Neural systems supporting the anticipation for expressive suppression and cognitive reappraisal. *Social Cognitive and Affective Neuroscience, 8*(8), 903–910.

Zald, D. H. (2003). The human amygdala and the emotional evaluation of sensory stimuli. *Brain Research Reviews, 41*(1), 88–123.