Research article

Loss-related mental states impair executive functions in a context of sadness

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A B S T R A C T

Stress and anxiety have been shown to temporally impair executive functions, but the role of other emotions, such as sadness, has been inconclusive. Moreover, the role of affect regulation in this relationship has not been extensively studied. The present research investigated whether certain types of mental states (mental output resulting from the use of affect regulation within a specific context or with respect to a specific material or theme) relative to the context of loss would predict impairment of executive functions. Participants were randomly assigned to read either a loss-related newspaper article inducing sadness or a neutral newspaper article. Results showed that low mental states relative to loss (maladaptive affect regulation) predicted impairment of executive functions following an induction of sadness, but not following the neutral induction. Conversely, high mental states (adaptive affect regulation) were not predictive of impairment of executive functions in both the sadness and neutral condition. These findings have implications for the boundaries within which emotion can disrupt high-order cognitive processes.

1. Introduction

Executive functions are a set of cognitive processes that regulate thoughts and actions. They include inhibition, working memory, and cognitive flexibility (Diamond, 2013). Induced stress and anxiety have been shown to temporally impair executive functions (Shields et al., 2016b). However, the role of other negative emotions, such as sadness, in impairing executive functions have been inconclusive (Blanchette and Richards, 2010; Shields et al., 2016a). In addition, the role of affect regulation and of context in this relationship has not been extensively studied (Aldao, 2013). In the present research, we investigated the impact of mental states relative to the context of loss—as a measure of affect regulation in context—as a moderating factor of the impact of an induction of sadness on executive functions.

2. Affect regulation and mental states

Affect regulation is the ability to modulate feeling states by reducing, increasing, or transforming them, or altering their meaning or effect on action or physical and mental health (Larsen and Prizmic, 2004). In line with Gross (2015), affect regulation is defined in this paper as an umbrella term, which includes the regulatory processes of emotion

regulation (i.e., selection and modulation of the emotional experience), coping (e.g., modulating stress responses), defense mechanisms (i.e., more unconscious and automatic reactions to actual or imagined threat), and mood regulation (i.e., strategies aiming at changing or repairing one's mood). Mental states are the mental output resulting from the use of affect regulation within a specific context or with respect to a specific material or theme (Bouchard et al., 2001; Beaulieu-Pelletier et al., 2013). The measurement of mental states is not an assessment of the regulation strategies used per se, but of the subjective experience, thoughts, and attitudes toward one's emotions and mental content that are expected to result from the use of certain coping, emotion regulation strategies, and defenses. For example, the mental state of an individual using reappraisal could be "I was trying to find a meaning to the situation", whereas the use of denial could lead to the mental state of "I did not feel affected at all by the situation". As such, the measurement of mental states does not require participants to report on the deliberate strategy they used to regulate their affect, as in many occasions people are unaware or do not notice that they are actually doing so (Cramer, 1998; Hart, 2014). It is assumed that a situation automatically triggers related mental representations, which are used to appraise the situation in terms of how threatening, hindering, or useful it is with respect to the individual's goal in the situation (Moors et al., 2013). It is this contextually based

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evaluation that gives rise to the affect and to specific affect regulation strategies and, in return, to mental states.

Adaptive and maladaptive mental states have been identified in the literature (Bouchard et al., 2001; Beaulieu-Pelletier et al., 2013). Maladaptive or low mental states include concrete thinking (CONC), low-defensive level (LoDef), and intermediate-defensive level (IntDef). CONC reflects a lack of connection to the emotional experience and a very low awareness of one's mental contents (e.g., "I did not think much about the situation"). LoDef is characterized by the activation of non-nuanced, intense, and hard-to-tolerate emotional representations, the use of immature defenses such as splitting or acting out as affect regulation, and feelings of being overwhelmed by emotion ("I was afraid of what I was feeling"). IntDef makes use of intermediate defenses such as denial, minimization, or emotional suppression, which distort emotional information by obliterating a part of the representations or by downplaying the personal meaning and the emotional charge of the representations (e.g. "I did not see any particular problem in the situation"). Maladaptive mental states have been associated with traits reflecting a lack of emotional representations and an urge to precipitated action, such as alexithymia and impulsivity, respectively. Low mental states were also found to be associated with emotion regulation difficulties and psychological and physical symptoms (Beaulieu-Pelletier et al., 2013; Bouchard et al., 2008; Marszal and Janczak, 2018; Tohme et al., 2020).

Adaptive or high mental states result from emotional situations triggering a large number of mental representations with nuanced affective components (rich appraisal) and the use of more mature affect regulation strategies and defenses (Bouchard et al., 2001; Beaulieu-Pelletier et al., 2013). High mental states include objective-rational (OBR), high-defensive level (HiDef), and reflective thinking (REF) (Beaulieu-Pelletier et al., 2013). The OBR state shows a third-person perspective that enables the person to take a distance from the emotional aspects of a situation and to focus mainly on its objective and external aspects ("I was mostly trying to organize my thoughts well"). [2] The HiDef state is characterized by its use of mature defenses (e.g., humor, altruism) and adaptive and mostly deliberate affect regulation strategies, such as cognitive reappraisal (e.g., "I thought the situation was difficult, but I felt the need to end it in a positive way, so that I did not dwell on the negative"). REF represents the capacity to elaborate and open oneself to the subjective experience (e.g., "I was becoming aware of what was happening inside myself, such as thoughts, sensations"). Globally, high mental states adequately organize emotional information without excessive distortion. The experience has the opportunity to be clarified and toned down, therefore reducing stress responses. Research has shown that high mental states were linked to a large range of positive and adaptive constructs related to the capacity to embrace negative emotions, such as distress tolerance and impulse control and to the use of emotional information in an effective fashion, such as authenticity, growing through a negative event, or empathic behaviour (Beaulieu-Pelletier and Philippe, 2016; Beaulieu-Pelletier et al., 2013; Bouchard et al., 2008; Tohme et al., 2020).

An apparent paradoxical account of adaptive mental states is that they are likely to result from processes requiring executive functions, such as elaborating, becoming aware, and reappraising (Raio et al., 2013). However, the use of executive functions does not imply that they are impaired for a subsequent use. Similarly, we argue that it is not the affect or the emotional experience per se that impairs executive functions, but the maladaptive process of it and the appraisal of threat that is activated in regard of the felt affect. Adaptive mental states may tone down the emotional experience, but not eliminate it, and often result in a greater

openness to the emotional experience by remaining aware and mindful about what one is feeling (Roth et al., 2018). It is maladaptive mental states that deny or distort the emotional experience and keep active threat appraisal and stress responses (e.g., Goldin et al., 2008), that can subsequently impair executive functions.

3. The present research

Stress induction has often been examined without much psychological meaning, such as cold pressor task or arithmetic thereby rendering the notion of context more difficult to circumscribe. In the present research, we use loss as a meaningful context of potential stress. The theme of loss was chosen, as it is a central, clinically relevant, and frequently encountered theme in people's lives related to a host of situations: the loss of a significant other, the loss of an important object, interpersonal rejection, and losses related to one's health, status or role (Philippe et al., 2011). Moreover, loss is one of the most stressful life events (Hobson et al., 1998) and is known to disrupt the regulation of the hypothalamic-pituitary-adrenal (HPA) axis and disturb cortisol secretion, the stress hormone (Meinlschmidt and Heim, 2005).

Mental states relative to the theme of loss were first evaluated. One week later, the presentation of a newspaper article inducing sadness relative to a theme of loss was shown to the participants. It was hypothesized that participants with low mental states with respect to loss would see their executive functions impaired by the loss and sadness induction, as indicated by a decrease in performance on an anagram task. Solving anagrams requires maintaining and manipulating information in working memory (Masicampo and Baumeister, 2011) and recruits cognitive flexibility (Campbell et al., 2008), both of which involve executive control (Diamond, 2013). Conversely, participants with high mental states related to loss should not show a reduced performance on the anagram task. A neutral condition was also included in which participants read a neutral article unrelated to a loss theme. It was expected that the neutral article would not evoke loss-related mental states and that, therefore, the executive functions would not be subsequently impaired and there should be no decreased performance on the anagram task in this condition. The present study was thus a quasi-experimental study in which participants were randomly assigned to a loss or a neutral induction and it was hypothesized that their level of mental states would predict impairment of their executive functions in the loss condition only.

4. Method

4.1. Participants

A total of 285 (222 females, 63 males) undergraduate and graduate students took part in the study.[3] Mean age was 28.30 years ($SD = 9.13$). A power analysis revealed that to use a multiple regression with six independent variables (conditions, performance baseline, low mental states, high mental states, low mental states X conditions, high mental states X conditions), expecting a small effect size of $f^2 = .05$, with a power of .80 and an alpha of .05, a sample size of 279 participants was required.

4.2. Session 1 measure

4.2.1. Mental states

The Mental States Task (MST; Beaulieu-Pelletier et al., 2013) was used to assess mental states. Participants were first asked to look at the 3BM card of the Thematic Apperception Test (Murray, 1943/1971), which depicts the huddled form of a person (age and sex unclear) lying

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[2] In the long run, the third-person perspective could, however, potentially impoverish emotional elaboration and verbalization (Beaulieu-Pelletier et al., 2013). The objective-rational mental state was categorized here in the higher mental states as the present study implies situational elicitation in which a third-person perspective could prove to be adaptive.

[3] Participants who failed to follow the instructions ($n = 3$), multivariate outliers ($n = 2$), and participants who took less than one minute to read the article ($n = 7$) were initially removed from this sample.

on the floor against a couch with his/her right arm bowed around the head. Beside the person, there is a revolver on the floor (blurred, so it is frequently seen as a set of keys or it remains unnoticed). This image was shown to implicitly evoke themes related to loss of a relationship and depressive experiences and emotions (Aronow et al., 2001). Participants wrote down a story that came up to their mind related to this image, and then responded to 24 items retrospectively assessing mental states during the story-writing task (*While I was completing this task*…). See Table 1 for the full list of items. The MST measures each of the six mental states, each assessed with four items. Items were responded to on a 7-point Likert scale (1 = *completely disagree*, 7 = *completely agree*). Alpha coefficients were .81 (CONC), .64 (LoDef), .66 (IntDef), .65 (OBR), .81 (HiDef), and .66 (REF), which is acceptable in light of the fact that the subscales are each composed of four items only and incorporate distinct facets of each mental state (Beaulieu-Pelletier et al., 2013). The Mental States Task has shown adequate factorial validity through confirmatory factor analyses across languages (Beaulieu-Pelletier et al., 2013) and cultures (Tohme et al., 2020) and adequate evidence of validity in both clinical and general population samples (Beaulieu-Pelletier et al., 2013; Beaulieu-Pelletier and Philippe, 2016; Górska and Marszał, 2014; Marszał and Jańczak, 2018; Tohme et al., 2020).

4.3. Session 2 material

4.3.1. Newspaper article induction

The participants in the experimental condition (*n* = 143) read a newspaper article used to induce sadness relative to a theme of loss. The article related a tragedy that took place in Montreal when a cement slab detached itself from the wall of the 18th floor of a downtown building

detached from the ceiling in the parking of the Montreal Olympic stadium. Nobody was injured, and no car was parked when the incident occurred. The number of words was the same for the two articles (630 words).

4.4. Session 2 measures

4.4.1. Positive and negative emotions

A short version of the Positive and Negative Affect Schedule (PANAS; Thompson, 2007) and four items assessing sadness-related emotions and two items assessing anger-related emotions were used to evaluate how participants felt *at the present moment*. All these items were categorized into four subscales: positive emotions (determined, inspired, alert, attentive, active), sadness-related emotions (sad, discouraged, -joyful, depressed), angry-related emotions (angry, rebellious, hostile) and anxious emotions (afraid, nervous, upset).[4] Two measurement moments were used in Session 2: 1) at the beginning of the experiment to serve as a baseline measure [Time 1] and 2) right after the reading of the article, in order to assess the emotions elicited by the article [Time 2].

4.4.2. Anagram performance

Participants were asked to solve a set of 25 anagrams before and another equivalent set of 25 different anagrams after the reading of the article. Participants were asked to unscramble each set of 4-letter anagram to form a common word during a 5-minute period. Anagram tasks have been used in past research on executive functions (e.g., Campbell et al., 2008; Masicampo and Baumeister, 2011). An impairment index was obtained by calculating the difference between the

Table 1. Full MST items.

Conc1	I did not have much to write about.
Conc2	I was not very inspired.
Conc3	The image was not telling me much.
Conc4	The material did not inspire any particular thoughts.
LoDef1	I was afraid of what I was feeling.
LoDef2	I was afraid of the state I would be in once I would have completed the task.
LoDef3	I loved and hated the character.
LoDef4	I saw or I thought about horrible, scary things.
IntDef1	I thought that what the character was going through was not that bad.
IntDef2	The character amused me.
IntDef3	I did not see any particular problem in the character's situation.
IntDef4	I found the character ridiculous to be affected that way.
Obr1	I was mostly trying to focus on well structuring the story's facts and their sequence.
Obr2	I was mostly trying to organize my thoughts well.
Obr3	I was focused on the facts and events of the story, like a detached observer.
Obr4	I was writing in a journalistic manner (ex: reporting the facts, the events that occurred, the characters, etc).
HiDef1	I thought that the situation experienced by the character was difficult, but that things always settle down.
HiDef2	I was repeating to myself that with time things would return to normalcy for the character.
HiDef3	I told myself that what the character was experiencing was difficult, but that he/she would not stay in this specific situation or position for a long time.
HiDef4	Although the character's situation was difficult, I felt the need to end my story in a positive way, so that I did not dwell on the negative.
Ref1	The character's situation moved me, but I was not overwhelmed with sadness.
Ref2	I was touched by what the character was experiencing, without being distressed.
Ref3	I was becoming aware of what was happening inside myself (thoughts, sensations, etc).
Ref4	The task triggered in me feelings that I was easily able to manage.

Note: Conc = Concrete, LoDef = Low defensive level, IntDef = Intermediate defensive level, OBR = Objective-rational, HiDef = High defensive level, Ref = Reflective.

and crashed onto a table where a couple was having dinner. The slab hit a middle-age woman on the head, wounding her fatally. Her helpless spouse was conducted to the hospital and was treated for a nervous shock. The participants in the control condition (*n* = 142) read a neutral newspaper article relative to an incident during which a concrete slab

[4] The item "ashamed" was discarded as it did not belong to any category and was not relevant to the present testing. It should be noted that results were virtually the same when this item was included in the analyses.

number of anagrams correctly solved at Times 1 and 2. A high score on this index indicates a greater impairment of the executive functions.

4.5. Procedure

All participants were randomly contacted through their institutional e-mail and explained that we were conducting an online study about personality. The incentive was that their participation allowed them to be entered into a draw for three prizes of $125. The two online sessions took place on our personal laboratory server and platform. During the first session, participants were asked to complete the MST online. The second session also took part online one week later in order to avoid any influence of the MST on the subsequent measures. Participants completed the PANAS and the first set of anagrams (Time 1). After five minutes of working on the anagrams, the page was automatically refreshed and participants were prevented from going back to the previous page. They were then randomly assigned to read either the emotional or neutral version of the newspaper article. Once they had finished reading the article, all participants were asked to click a specific button. The time spent reading the article was recorded to ensure that the participants were carefully reading it. Finally, they were asked to complete the PANAS again and were administered the second set of anagrams on which they were also allowed to work for five minutes (Time 2), after which the page was automatically refreshed.

4.6. Ethics statement

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the University of Montreal. Informed consent was obtained from all individual participants included in the study.

5. Results

5.1. Manipulation check[5]

Paired t-tests revealed that sadness and anger were higher after the emotional condition at Time 2 than at Time 1, but not in the neutral condition (see Table 2). Positive emotions were lower at Time 2 than at Time 1 in both conditions and anxious emotions did not show any significant change between Times 1 and 2 in the emotional condition, but were significantly reduced in the neutral condition. In sum, the emotional article about loss specifically targeted sadness and anger emotions, whereas the neutral article did not. Paired t-test analyses also revealed that anagram performance was lower after reading the article about loss than before, confirming an impairment of executive functions of a moderate effect size. For the neutral condition, there were no significant differences in anagrams performance after as compared to before reading the neutral article. These results support the fact that the emotional article about loss was effective in impairing executive functions, whereas the neutral article did not yield such effect.

5.2. Mental states and impairment of executive functions

To examine what types of mental states were associated with an impairment of the executive functions, a multiple hierarchical regression analysis was conducted. Impairment on the anagrams served as the

dependent variable. At Step 1, Performance on anagrams at Time 1, Conditions (0 = neutral; 1 = emotional), and Low and High mental states were entered. At Step 2, the interaction terms Conditions X Low mental states and Conditions X High mental states were included as independent variables. Results (see Table 3) revealed that, at Step 1, Performance on anagrams at Time 1 significantly predicted impairment (β = -.19, p = .001), suggesting that those with a high score on anagrams at Time 1 were less impaired at Time 2. A main effect of Conditions was also obtained (β = .12, p < .05). Low (β = -.08, ns) and High (β = .05, ns) mental states were unrelated to impairment. The model at Step 1 was significant, $F(4, 280) = 4.53$, $R^2 = .061$, $p < .01$. At Step 2, the interaction term Conditions X Low mental states (B = 1.31, SE = .43, $t[278]$ = 3.09, p = .002) significantly predicted impairment, $F_{change}(2, 278) = 5.10$, $R^2_{change} = .033$, $p < .01$, whereas the interaction term Conditions X High mental states did not (B = 0.47, SE = .41, $t[278]$ = 1.15, p = .25). Analyses of the simple effects and plotting of the interaction term Conditions X Low mental states (see Figure 1) showed that when Low mental states were high (+1SD), participants in the emotional condition displayed greater impairment than participants in the neutral condition, $t(278) = 3.64$, $p < .001$. When Low mental states were low (-1SD), there was no difference in impairment between the two conditions, $t(278) = 0.77$, $p = .44$.[6] The interaction effect explained 3.3% of the variance, while this may seem small, this is the variance explained after accounting for the main effect of conditions and taking into account that individuals with high mental states and reduced low-mental states did not contribute to the effect. The real contribution of the low mental states to impairment of executive functions may be better observed with the following ancillary analyses.

Ancillary analyses were conducted to examine whether certain mental states might explain impairment better than others. The same regression presented above was again conducted using participants in the emotional condition only, this time including the six individual mental states at Step 2. Results revealed that CONC (β = .17, $t[134]$ = 1.84, p = .069), LoDef (β = .18, $t[134]$ = 2.21, p = .029) and IntDef (β = .21, $t[134]$ = 2.42, p = .017) each independently predicted impairment at least at $p < .10$, $F(3,134)$, = 5.00, $p < .01$, total $R^2 = .09$, whereas OBR (β = -.13, p = .11), HiDef (β = -.01, p = .91) and REF (β = .12, p = .28) were unrelated to impairment. Thus, low mental states contributed to explain 9% of the reduction in performance in anagrams, which is appreciable. Overall, these findings suggest that all low mental states put one at risk of impairment of the executive functions, whereas all high mental states seem to protect from it. Finally, we examined whether the level of emotion experienced could explain the results. Controlling for emotions (sadness, anger, anxiety, or positive emotions) or their interactions with conditions did not affect the results (see Table 4).

6. General discussion

The goal of the present research was to investigate the role of mental states in impairing executive functions following an induction of sadness. Overall, results suggest that recruiting low mental states when dealing with an emotional situation of loss makes one subsequently more vulnerable to an impairment of executive functions, as indexed by anagrams. Low mental states potentially trigger an appraisal of threat and a stress response that is responsible for the subsequent impairment in executive functions. The cognitive resources required by low mental states may also be more taxing in terms of prefrontal capacity and reduce executive functions (but see Sarigiannidis et al., 2020). Conversely, high mental states appear to better organize emotional information and keep emotion under control. As a consequence, no appraisal of threat is triggered and the affect is not experienced as stress, which therefore does not

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[5] Results revealed no sex differences on all mental states, anagram performance, or emotions, except on IntDef, OBR, the positive emotional subscale measured at Time 1 and on the sadness subscale at Time 2. Men had higher scores than women on all these variables, except for lower sadness at Time 2. Effect sizes were medium. Despite these mean differences, controlling for sex did not alter the results and no significant interaction with sex was obtained. Therefore, this variable was not further investigated.

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[6] A second hierarchical regression analysis was conducted to examine whether the impairment effect could be due to the emotions elicited by the article induction rather than by mental states. Emotion was not related to impairment and did not alter the effect of low mental states on impairment.

Table 2. Means, Standard Deviations, and Paired t-tests between Times 1 and 2 Emotions and Anagrams.

| Variables	Conditions	M (SD)	M (SD)	t(283)	d
		Time 1	Time 2		
Emotions					
Sadness	Emotional	2.20 (.83)	2.80 (.83)	10.63**	1.62
	Neutral	2.28 (.90)	2.28 (.82)	0.04	
Anger	Emotional	1.63 (.84)	1.94 (.85)	4.84**	.82
	Neutral	1.60 (.73)	1.60 (.74)	0.08	
Anxiety	Emotional	2.07 (1.00)	2.00 (.99)	-1.01	
	Neutral	2.06 (.92)	1.84 (.89)	-3.32**	.54
Positive Emotions	Emotional	2.75 (.80)	2.27 (.81)	-9.35**	1.33
	Neutral	2.84 (.82)	2.56 (.87)	-5.59**	.74
Anagrams	Emotional	13.64 (4.08)	12.74 (4.54)	-3.13**	.47
	Neutral	13.49 (4.48)	13.45 (5.49)	-0.13	

Note. $n_{emotional} = 142$ and $n_{neutral} = 143$. *$p < .05$, **$p < .01$.

Table 3. Results of the multiple regression predicting changes in anagram performance at T2.

Independent variables	B	SE	β	t(278)
Step 1				
Anagram Performance T1	-0.16	0.049	-.19	-3.28**
Conditions (0 = Emotional; 1 = Neutral)	0.86	0.42	.12	2.05*
Low mental states	-0.30	0.22	-.081	-1.38
High mental states	0.19	0.21	.053	0.91
Step 2				
Low mental states X Conditions	1.31	0.43	.24	3.09**
High mental states X Conditions	0.47	0.41	.088	1.15

Note. Dependent variable is changes in anagram performance between T2 and T1.
*$p < .05$, **$p < .01$.
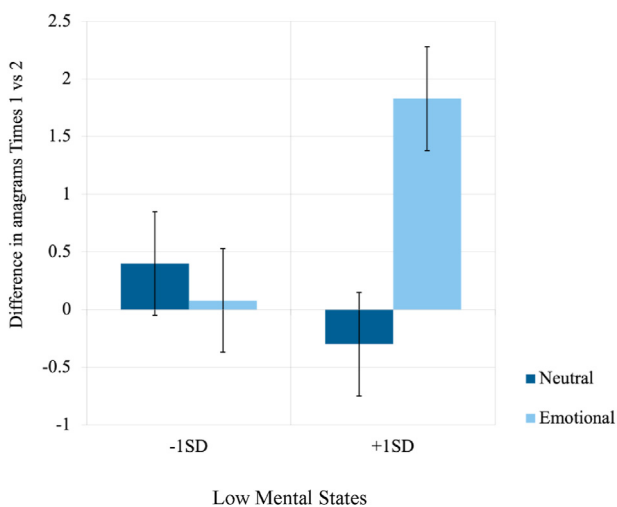
Figure 1. Plotting of the interaction Conditions X Low mental states on Anagram Performance.

impair executive functions subsequently. Neuroimage studies would be needed to examine the psychological processes at play (e.g., activation of amygdala or not with low mental states in a context of loss), as this appraisal process appears to be rather automatic and to occur outside of awareness and thus, impossible to capture with self-reports of emotion. Indeed, reported emotional experience did not explain the results obtained in this study. Another alternative would be to use vagally mediated heart rate variability (vmHRV) as a marker of stress following an induction of loss (Thayer et al., 2012). vmHRV could then act as a

mediator between low mental states and impairment in executive functions.

Our results are reminiscent of those of Richards and Gross (2000) who manipulated emotion regulation strategies and showed that the use of suppression while watching a loss-related film clip reduced memory for details of the film compared to normal watching. The present study extends those results by showing that individual differences in affect regulation regarding a loss context also impair performance on a subsequent task requiring executive functions. Together, these findings suggest that other negative emotions than stress and anxiety can impact executive functions, and this depends on how the affect of the induction is regulated.

Our findings also extend the literature on moderators of the relationship between stress and executive functions. While most moderators uncovered are typically stable variables, such as demographic or personality traits (Plieger and Reuter, 2020), the present study is one of the first to highlight that the relationship between stress and executive functions may be best conceptualized as a Person X Stressor interaction. Particularities about the stressor may interact with a person capacity to regulate that particular kind of stressor, which will in turn determine one's impairment or not on executive functions. This contextualization of the stressor within the regulation specificities of a person may shed light on the various inconsistent findings of the literature on stress and executive functions (Blanchette and Richards, 2010).

The method used in the present study, however, departs from the typical stress-inducing tasks using cold pressor, timed arithmetic performance, or social stress test. The induction of loss we used can be a profoundly distressing experience and one that can be difficult to regulate given the personal connotation and memories it can trigger (Philippe et al., 2009). However, it may also induce other emotions (e.g., distress) that would not be induced with other more impersonal stress-inducing

Table 4. Interactions between emotions and conditions on changes in anagram performance at T2.

Independent variables	B	SE	β	t(266)	p
Anagram Performance T1	-0.188	0.049	-0.223	-3.862	<.001
Conditions (0 = Emotional; 1 = Neutral)	0.738	0.451	0.102	1.637	0.103
Low mental states	-0.855	0.285	-0.233	-2.997	0.003
High mental states	0.013	0.282	0.004	0.047	0.963
Difference sadness	0.067	0.367	0.019	0.184	0.854
Difference anxiety	-0.105	0.274	-0.029	-0.385	0.701
Difference positive emotions	-0.154	0.282	-0.043	-0.546	0.586
Difference Anger	-0.258	0.313	-0.071	-0.823	0.411
Sadness X Conditions	-0.899	0.598	-0.147	-1.503	0.134
Anxiety X Conditions	1.122	0.49	0.184	2.289	0.023
Positive X Conditions	-1.043	0.448	-0.183	-2.329	0.021
Anger X Conditions	0.016	0.544	0.003	0.029	0.977
Low mental states X Conditions	1.241	0.423	0.225	2.936	0.004
High mental states X Conditions	0.482	0.412	0.091	1.169	0.243

Note. The significant interactions between anxiety or positive emotions and conditions showed that these emotions contributed to a decrease in performance in the control condition only.

tasks. Therefore, it is unclear whether the present findings would be replicated with more classical stressful tasks or whether other factors (e.g., previous stressful life events) may moderate the effects obtained. Future research will be needed to further investigate these possibilities.

7. Limitations and conclusions

The present research suffers from some limitations. First, only university students were recruited, which limits the generalization of the results. Future research should replicate the present findings with community-dwelling and clinical populations. A second limitation is that many more females participated in the present study compared to males. While controlling for sex did not alter the results and no significant interaction with sex was obtained, the fact that the sample was composed of only 22% of males might have reduced power to detect sex differences. Future research is needed to investigate potential sex differences in mental states and executive functions. A third limitation is that the present research focused on the theme of loss only. Although this theme is a relevant clinical one, it would be of great interest to examine the role of mental states in impairing executive functions relative to other affectively relevant themes such as injustice, anxiety, and sexuality. Finally, no other measures of individual differences were included. Future research should take into account other potential variables that could influence executive functions, such as personality traits, self-control capacities, or fluid intelligence, in order to evaluate the independent contribution of mental states in impairing executive functions.

Declaration

Author contribution statement

Genevieve Beaulieu-Pelletier, Marc-André Bouchard, Frederick L. Philippe: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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