Journal of Affective Disorders 292 (2021) 328–336

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

How long do mood induction procedure (MIP) primes really last? Implications for cognitive vulnerability research

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ARTICLE INFO

Keywords:
Mood induction procedure (MIP)
Temporal persistence
Sad mood/depression
Cognitive vulnerability
Cognitive reactivity

ABSTRACT

Background: Mood Induction Procedures (MIPs) are used widely in research on cognitive vulnerability to depression. Although empirical evidence supports certain MIPs as effective, little research has evaluated whether MIP-induced sad moods are sufficiently persistent. This study aimed to determine (1) how long an MIP-induced mood lasts according to commonly used operational definitions and (2) whether these findings vary according to the type of MIP used.

Methods: Four-hundred-and-one undergraduate students were randomly assigned to one of three commonly used sad MIPs (music, memory, music+memory) or to one of three matched neutral MIPs. Mood was repeatedly measured immediately prior to and following the MIP.

Results: Results did not support the widely held belief that commonly used MIPs induce a sufficient and persistent sad mood. The memory-related MIPs induced the most persistent sad mood. Based on the majority of operational definitions, however, induced mood effects did not last longer than 4 min, regardless of MIP type.

Limitations: Future studies should examine additional factors that may have affected the trajectories observed in the current study (e.g., task completed in between mood measurements) and in vulnerable (e.g., past-depressed) populations.

Conclusions: This study constitutes an important first step in validating the use of MIPs in cognitive vulnerability research and provides researchers with important information on future study designs. More important, the study raises doubt about the validity of various conclusions drawn from some MIP studies and calls into question the theoretical conceptualizations of depression that are based on potentially biased results and a possibly incomplete literature.

Public Significance Statement

This study suggests that mood induction procedures (MIPs), intended to induce dysphoria, do not produce sad moods that last long enough for researchers to adequately study their effects. It is thus possible that some researchers who have used MIPs have drawn incorrect conclusions or decided not to publish results because the MIPs used did not produce long-lasting sad moods. Therefore, areas of research reliant on MIPs can become biased.

1. Introduction

Having an effective and valid method of experimentally manipulating mood is crucial for the empirical study and conceptualization of the effect of mood on countless psychological processes, such as cognition (Choma et al., 2012), behaviour (van Strien et al., 2013), and interpersonal functioning (Forgas, 2013). To this end, researchers have developed Mood Induction Procedures (MIPs; Lench et al., 2011). MIPs are designed to induce either a positive or a negative affective state in participants to investigate the effect of mood on psychological constructs. There are numerous classes of MIPs, as well as myriad permutations of MIP protocols within each class (e.g., musical,

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[1] The first author was supported by the Social Sciences and Humanities Research Council of Canada (SSHRC), and the second author was supported by an Insight Grant from SSHRC. Portions of these findings were presented as a poster at the 2018 International Congress of Applied Psychology, Palais des Congrès de Montréal, Montréal, QC, Canada. We have no conflicts of interest to disclose.

https://doi.org/10.1016/j.jad.2021.05.047
Received 13 November 2020; Received in revised form 13 May 2021; Accepted 23 May 2021
Available online 26 May 2021

autobiographical memory, film; Westermann et al., 1996).

Substantial empirical evidence has supported the effectiveness of certain classes of MIPs (for a review, see Westermann et al., 1996)—that is, participants' moods[2] significantly change following the MIP. However, very little research has investigated the temporal persistence of an MIP-induced sad mood. Despite this, many researchers who use MIPs seemingly interpret their results under the assumption that their "effectively induced" mood state lasted long enough for participants to complete their measures or tasks of interest. Given the theoretical importance and widespread use of MIPs in depression research, the lack of knowledge about the validity of the temporal persistence of their effects is concerning, both conceptually and methodologically. This is because the persistence of an induced mood is essential. If the induced mood dissipates before the task or measure has been completed, the results may not accurately demonstrate the effects of sad mood on the construct of interest. Thus, without an accurate appraisal of how long a mood effect can reliably be assessed, some of the conclusions drawn from extant research on mood effects that use MIPs may be inaccurate.

1.1. Conceptual importance of MIPs in cognitive vulnerability research

MIPs have been used widely across diverse research areas (Joseph et al., 2020) and are particularly crucial in the study of cognitive vulnerability to depression (e.g., Ingram et al., 1998). Cognitive vulnerability refers to the idea that some individuals exhibit latent negative cognitive structures (i.e., the diathesis) that become activated during stressful situations (i.e., the stress); in turn, these activated cognitive structures are posited to activate negative cognitive processes that contribute to the development, maintenance, and recurrence of depression (Beck, 1967; Beck et al., 1979; Dozois and Beck, 2008). Such activation of negative information-processing biases because of a stressor or sad mood is termed cognitive reactivity. According to theories of cognitive vulnerability, individuals who possess the diathesis of these latent negative cognitive structures are particularly vulnerable to depression (Beck, 1967; Beck et al., 1979).

MIPs are thus considered an effective avenue for studying the diathesis-stress model of cognitive vulnerability to depression because MIPs purportedly activate latent negative cognitive structures (e.g., maladaptive schemas, associative cognitive networks) experimentally, in a manner similar to the way in which a stressful life event would. For example, seminal cognitive vulnerability studies (Ingram et al., 1994; Ingram and Ritter, 2000) found that individuals with prior depression (but who were not currently depressed) showed significantly more maladaptive cognitive processing than did never-depressed controls only after being experimentally manipulated into an MIP-induced sad mood.

1.2. Reliability and validity of MIPs

Numerous studies have provided evidence that some MIPs effectively induce sad mood states (Gerrards-Hesse et al., 1994; Martin, 1990; Westermann et al., 1996). However, the overall validity and reliability of these procedures is currently unknown, which is particularly concerning given the so-called replication crisis in social sciences research (Open Science Collaboration, 2015). For example, a variety of criteria have been used to operationally define an MIP-induced sad mood in cognitive vulnerability research. Most commonly, researchers measure mood prior to and following the administration of the sad MIP and then statistically compare those pre- and post-MIP mean mood scores. If these analyses indicate that the post-MIP mood is significantly sadder than the pre-MIP mood, researchers conclude that the sad mood was successfully induced (e.g., Beevers et al., 2011; Jarrett et al., 2012).

In other studies, researchers compare the mean post-MIP mood scores of the sad MIP condition and a neutral MIP condition (e.g., Beevers and Meyer, 2008; Ingram and Ritter, 2000). The implication is that, if the sad MIP was successful, individuals who were exposed to the sad MIP should report significantly greater levels of sadness than those who were not exposed. If this pattern of results is observed, the sad mood is deemed to have been successfully induced.

In other cases, a third method is used: Some researchers select an absolute minimum mood change value that participants must evince on the mood measure pre- to post-MIP for the MIP to be considered effective (e.g., Newman and Sears, 2015; Singer and Dobson, 2007).

1.3. Temporal persistence of MIPs

As mentioned, many researchers seem to work under the assumption that the induced sad mood persists for the entirety of their measures. That is, researchers typically do not confirm that a successfully induced mood state persisted until the relevant task or measure was completed (e.g., Beevers et al., 2009; Gemar et al., 2001).

This lack of confirmation complicates the matter of MIP use and has critical empirical and theoretical implications. To reiterate, theories of cognitive vulnerability posit that sad moods activate latent depressogenic cognitive structures, giving rise to cognitive reactivity, which purportedly contributes to the development, maintenance, and recurrence of depression. According to information-processing theoretical frameworks of depression (e.g., Ingram, 1984; Teasdale, 1988), sadness would necessarily continue to be present for as long as cognitive reactivity remains active. It then follows that, if an induced sad mood does not persist for the entirety of a measure of cognitive reactivity, depressogenic cognitive structures may not remain activated. If this were the case, cognitive reactivity may not be observed. Researchers may then incorrectly conclude that there was no association between study variables and cognitive reactivity.

At first glance, this may actually seem to lend stronger support for cognitive vulnerability research. That is, if seminal MIP studies of cognitive vulnerability observed cognitive reactivity in response to an MIP-induced sad mood, even when there was a non-persistent MIP mood effect, this would only provide support that the effect is more robust than previously thought. Indeed, it would suggest that the effect sizes of MIP-induced sad moods eliciting cognitive reactivity are large enough to withstand greater error variability (i.e., variability resulting from a non-persistent induced mood).

The greater concern, then, is the impact that non-persistent MIP effects may have on lines of cognitive vulnerability research that test more nuanced relations with potentially smaller effect sizes. One can only imagine how many studies have not been published and how many lines of inquiry have been abandoned when supposedly effective MIPs did not elicit a hypothesized response (the file-drawer effect). Thus, the fact that few researchers confirm whether an induced sad mood is sufficiently persistent is potentially problematic: It raises doubt about the validity of the findings of some MIP studies and calls into question the theoretical conceptualizations of depression that are based on potentially biased results and a possibly incomplete literature.

1.4. Research investigating the temporal persistence of MIP-induced sad moods

Very few studies have specifically investigated the temporal persistence of MIP-induced moods, and almost none have used a methodology similar to that used in seminal cognitive vulnerability research. As an

[2] It is worth noting the terminology used to describe MIP effects in seminal cognitive vulnerability research. This literature tends to refer to the effects of sad MIPs as "sad moods." The authors of this article recognize that an induced state of sadness may be characterized by more current affective sciences conventions as an emotion, rather than as a mood (Watson, 2000; Rottenberg and Gross, 2003). For the sake of consistency and comparison with the terminology used in cognitive vulnerability literature, however, this article will refer to MIP-induced sad *moods*.

example of one exception, Kuijsters et al. (2016) investigated the trajectories of the effects of sad mood following three sad MIPs: a short film segment, a long film segment, and a slideshow of images that were previously rated as high on sadness. Sad mood was significantly induced up to and including the measurement at 2 min post-MIP for the long film segment, and up to 6 min post-MIP for the short film segment. Though a sad mood was significantly induced immediately following the MIP for the slideshow of images, it was not maintained by the measurement at 2 min post-MIP.

These findings—that certain MIP-induced mood changes may not persist for even as long as two minutes—provide a stark illustration of what could be a major methodological flaw of research employing MIPs. It is thus crucial to investigate the temporal persistence of the effects of MIPs used in influential cognitive vulnerability studies, while additionally—as much as possible—replicating the methodologies of this seminal research.

1.5. The current study

The aim of this study was therefore to begin filling gaps in the literature by assessing the reliability and validity of commonly used MIP methodologies in influential cognitive vulnerability to depression studies. The primary objective was to determine (1) how long an MIP-induced mood lasts according to the most commonly used operational definitions of a successfully induced sad mood and (2) whether these findings vary according to the type of MIP used.

The literature (e.g., Martin, 1990; Westermann et al., 1996) suggests that some classes of MIPs (e.g., film) may be most effective and that numerous methodological differences can influence effect sizes and/or potentially introduce demand characteristics. It is important to note that this study aimed not to determine the temporal persistence of the effects of the most effective MIPs, but rather to determine whether the MIPs that were used in early, seminal cognitive vulnerability studies provided a sufficiently persistent mood effect. The ultimate objective of this aim was to determine whether some conclusions drawn from cognitive vulnerability research may be inaccurate and whether certain lines of inquiry may have been abandoned as a result of unknowingly eliciting a non-persistent MIP-induced mood.

2. Method

2.1. Participants

Undergraduate students were recruited through a research participant pool. Participants completed the study in a group setting, though they were stationed at individual computers with dividers that provided privacy. A maximum of five participants completed the study at the same time. Participants received a research credit as a partial fulfilment of their introductory psychology course.

The final sample included 401 participants (238 females; 160 males; 1 self-identified as transgender; 2 did not identify a gender).[3] Participants ranged in age from 17–58 years (M = 18.53, SD = 2.46). Their years of education ranged from 11–17 (M = 12.29, SD = 0.74). Of all the participants in the final sample, 41.5% identified as Caucasian, 22.5% Chinese, 10.3% South Asian, 18.3% as Other, and 6.8% indicated that they were multi-ethnic (by reporting more than one ethnicity).

[3] The sample size for this study was determined based on the sample size required to conduct complex statistical analyses not reported in this article. The resultant sample size (N = 401, $ns \cong 100$) provides sufficient power to detect small-medium effects with the paired-samples t-tests used in the current study, as calculated using an a priori power analysis using G*Power. Given that effects sizes for changes in mood from prior to and following sad mood induction procedures (MIPs) tend to be large, the N = 401 sample size was deemed to be adequate.

2.2. Materials

2.2.1. Mood induction procedures (MIPs)

Six MIPs were used in the study. Participants were exposed to one of three sad MIPs used in influential cognitive vulnerability research (e.g., Ingram et al., 1994; Segal et al., 1999) or to one of three matched-control, neutral MIPs. Consistent with the procedures used in these studies, MIPs were 7 min in length. MIP instructions were provided through over-ear headphones and via corresponding text on the computer screen. The experimental conditions (sad MIPs) included a sad music MIP, a sad autobiographical memory MIP, and a combination of both the sad music and sad memory MIPs. The procedures of the three neutral-MIP conditions were identical to those of the sad-MIP conditions, though the content of the memory recalled and/or music listened to was neutrally valenced.

The timing, music, and instructions used in the experimental conditions were chosen based on the protocols most commonly used in MIP research studies conducted by leading depression researchers (e.g., Jarrett et al., 2012; Lethbridge and Allen, 2008; Segal et al., 1999). The timing, music, and instructions used in the control conditions were chosen based on protocols that closely resembled sad-MIP protocols (e.g., Bates et al., 1999). Details of each MIP procedure can be found in Appendix A in Supplementary Materials.

2.2.2. Sad mood

A modified visual analog scale (VAS; Luria, 1975) was used to measure mood. The VAS is a 100-mm line, with anchors of no sadness at all on the left end of the line and most sadness imaginable on the right. Participants were instructed to "indicate the degree of sadness [they were] currently experiencing by clicking at the appropriate point on the line." Participants were also asked to "please answer as quickly and accurately as possible," to ensure that participants did not spend too much time ruminating about their mood, thereby potentially intensifying their sad mood (Thomsen, 2006). The score for each VAS ranges from 0 to 100 (i.e., the number of millimetres from the left end of the line), with greater scores indicating greater levels of sad mood. Mood scores were calculated by measuring the distance (mm) from the left-hand end of the line. VASs are used widely in depression research employing MIPs and have exhibited strong reliability and validity (e.g., Jarett et al., 2012; Lethbridge and Allen, 2008).

Test re-test reliability of the VAS was assessed in three ways: A significant bivariate correlation of the two pre-MIP VAS scores, conducted using the full sample (N = 401), indicated very strong reliability, r = .93, $p < .001$. Paired-samples t-tests using the same data indicated that there was no significant difference between the first (M = 23.76) and second (M = 23.93) pre-MIP VAS scores, $t(400) = -0.43$, p = .670. Using all 8 VAS measurements in the subsample of participants who were exposed to the neutral MIP conditions (n = 98), a two-way mixed-effect ANOVA model intraclass correlation coefficient (ICC) with an absolute agreement coefficient (Qin et al., 2019) produced an ICC estimate of .85 and 95% confidence intervals that indicated good reliability ([95% CI = .810 to .888]; see Koo and Li, 2016).

2.2.3. Demographics

A questionnaire designed by the researchers for the current study was used to determine various demographic (age, gender, ethnicity, and number of years of education, English as first language) and clinical (history of treatment for psychological problems) characteristics.

2.3. Procedure

After providing their informed consent, participants were directed to a room with computer stations; each station had dividers that provided privacy. Participants completed the entire study online at their workstation with over-ear headphones, which helped to minimize distractions as well as prevent participants from knowing that there were

different study conditions. Participants were randomly assigned to one of six conditions.[4]

To increase the likelihood that participants paid attention to and engaged with the MIP, they were first presented with a brief video description of the importance of actively engaging in the study and were asked to put away distracting items. All participants then completed the visual analog scale (VAS) mood rating to assess baseline mood. They then completed one of the two 9-item Dysfunctional Attitudes Scale (DAS) Short Forms (i.e., DAS-SF_1 or DAS-SF_2) before completing another VAS and then completing their assigned MIP (see Appendix B in Supplementary Materials for a description of the DAS and a rationale for its inclusion in this study). Participants completed a third VAS immediately following the MIP, and were then administered the alternate DAS-SF.

Participants then completed the remaining 82 items from the original, 100-item DAS as filler items to replicate the methodology that participants often completed in seminal cognitive vulnerability research. Participants recorded their mood ratings on VASs at 2, 4, 6, 8, and 10 min post-MIP in between completing the filler DAS items.

Following this portion of the study, participants completed a demographic questionnaire as well as other measures (e.g., Beck Depression Inventory-II; BDI-II; see Appendix C in Supplementary Materials for a description) that were used to answer additional research questions not addressed in this article. Finally, participants underwent a positive MIP to ensure their moods returned to initial levels. Participants were individually debriefed with respect to the purpose of the study and were provided with course credit for participation. The debriefing protocol was designed to ensure that no participant left feeling sad or distressed. The entire study took approximately 1 hour to complete.

3. Results

Demographic and clinical characteristics of the six MIP groups are presented in Tables 1 and 2. Participants did not differ significantly in age, $F(5, 395) = 0.23$, $p = .951$; years of education, $F(5, 394) = 0.50$, $p = .778$; or BDI-II scores, $F(5, 394) = 1.20$, $p = .311$, across the six MIP conditions. As indicated in Table 2, participants similarly did not differ significantly across the MIP conditions by gender, ethnicity, English as a first language, history of therapy/counselling, or history of taking medication for an emotional or psychological problem.

The observed mean mood scores for each of the MIP conditions (at all eight time points) are presented in Fig. 1. As previously mentioned, a variety of criteria are used in cognitive vulnerability research to operationally define a successfully induced sad mood. The assessment of how long an MIP-induced sad mood lasts thus varies depending on the operational definition used. Duration of a sad mood was therefore assessed in three different ways, by using the three most commonly used operational definitions of a successful sad mood induction.

1 One of the most commonly used criteria is that pre- and post-MIP VAS scores significantly differ. Therefore, for each of the three sad MIP conditions, six paired-samples *t*-tests were conducted to compare each of the mean post-MIP VAS scores to the mean pre-MIP VAS score to determine the time points at which those mean VAS scores differed. (See Appendix D for the rationale of the decision to run multiple *t*-tests.) Table 3 shows the time points at which the mean post-MIP VAS scores do and do not significantly differ from the mean pre-MIP VAS scores, separately for each of the three sad MIP conditions.
2 A second commonly used criterion for operationalizing a successful sad mood induction is that the mean post-MIP mood scores of participants who were exposed to a sad MIP differ significantly from the mean post-MIP mood scores of those who underwent a control or neutral MIP (e.g., Beevers and Meyer, 2008; Ingram and Ritter, 2000). Therefore, in order to determine the time points at which the MIP successfully induced a sad mood according to this criterion, a series of three one-way ANOVAs was conducted to compare the mean VAS scores of each of the three sad MIP conditions with the mean VAS score of a combined neutral condition prior to and also at 0, 2, 4, 6, 8, and 10 min post-MIP (see Appendix E for the rationale explaining the decision to combine neutral conditions). Table 3 presents the time points at which the mean VAS scores of the sad MIP conditions do and do not significantly differ from the mean VAS scores of the combined neutral MIP condition, separately for each of the three sad MIP conditions.
3 A third criterion for operationalizing a successful sad mood induction that has been used in sad-MIP research is a minimum absolute change on the mood measure from pre- to post-MIP. Minimum changes in mood of 10 mm and 20 mm on a VAS have often been used in cognitive vulnerability research to indicate the success of a sad MIP (e.g., Martin, 1990; Newman and Sears, 2015). The time points at which a sad mood is and is not deemed to be induced (at the group level) based on the criterion of a minimum absolute change in mood pre- to post-MIP of 10 mm and 20 mm are presented in Table 3, separately for each of the three sad MIP conditions. At the individual level, the percentage of participants for whom a sad mood was successfully induced based on these two operational definitions (i.e., a 10- or a 20-mm change in mood pre- to post-MIP) at each of the post-MIP time points is presented in Table 4.

Overall, the results indicate that, for participants assigned to the music MIP condition, a sad mood was not effectively induced for longer than 4 min post-MIP, regardless of the operational definition used (see Table 3).[5] Additionally, when using the criterion of at least a 10 mm change pre- to post-MIP, less than half of participants assigned to the music MIP would be considered as exhibiting an effectively induced sad mood immediately following the MIP. When the minimum pre- to post-MIP change value of 20 mm was used, only 23% of participants would have been considered as displaying an effectively induced sad mood immediately following the MIP.

For participants assigned to the memory MIP condition, a sad mood could be considered effectively induced anywhere between 0 and 10 min post-MIP, depending on the operational definition used (see Table 3). When using the criterion of at least a 10 mm change pre- to post-MIP, 69% of participants assigned to the memory MIP would be considered as reporting an effectively induced sad mood immediately following the MIP. When the minimum pre- to post-MIP change value of 20 mm was used, 44% of participants would have been considered as displaying an effectively induced sad mood immediately following the MIP.

Finally, for participants assigned to the music+memory MIP condition, a sad mood could be considered effectively induced anywhere between 0 and 8 min post-MIP, depending on the operational definition used (see Table 3). Similar to participants in the memory MIP condition, 71% of participants assigned to the music+memory MIP would be considered as displaying an effectively induced sad mood, when using the criterion of at least a 10 mm change pre- to post-MIP. When the

[4] Because the three neutral MIP conditions were included only to evaluate whether repeated measurement of mood affects mood ratings, fewer participants were required for the neutral MIP conditions. Random assignment therefore occurred based on a group stratification that considered the non-equivalent proportion of participants in the experimental versus control groups.

[5] Exploratory follow-up analyses indicated that the trajectories of the induced sad mood effects were similar across participants exhibiting low versus high depression symptom severity (see Appendix F in Supplementary Material). Readers are advised, however, that these findings are not interpretable, owing to low power and violations of assumptions such as equal sample sizes. Readers are thus cautioned against drawing conclusions from these exploratory follow-up analyses.

Table 1
Continuous demographic and clinical variables by MIP condition.

Variable	Sad Music (n = 97)		Sad Memory (n = 102)		Sad Memory+Music (n = 98)		Neutral Music (n = 35)		Neutral Memory (n = 35)		Neutral Memory+Music (n = 34)	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Age	18.67	(4.17)	18.60	(1.89)	18.53	(1.80)	18.49	(1.12)	18.29	(0.79)	18.26	(0.62)
Education	12.21	(0.61)	12.36	(0.77)	12.29	(0.86)	12.34	(0.80)	12.29	(0.79)	12.24	(0.50)
BDI-II	14.38	(9.54)	14.88	(10.09)	13.96	(9.28)	14.86	(10.06)	15.83	(10.25)	10.82	(9.60)

Note. BDI-II = Beck Depression Inventory-II. Education = years of completed education.

Table 2
Discrete demographic and clinical variables by MIP condition and differences across conditions.

Variable	Sad Music (n = 97) %	Sad Memory (n = 102) %	Sad Memory+Music (n = 98) %	Neutral Music (n = 35) %	Neutral Memory (n = 35) %	Neutral Memory+Music (n = 34) %	Test Statistic	*p*
Gender							[a]χ (15) = 8.51	.902
Female	61.9	54.9	61.2	54.3	54.3	70.6		
Male	37.1	43.1	38.8	45.7	45.7	29.4		
Transgender	0.0	1.0	0.0	0.0	0.0	0.0		
Not specified	1.0	1.0	0.0	0.0	0.0	0.0		
Ethnicity							[a]χ^2 (25) = 23.82	.530
Caucasian	39.2	39.2	44.3	34.3	40.0	55.9		
Chinese	29.9	16.7	21.6	31.4	17.1	17.6		
South Asian	10.3	15.7	8.2	8.6	5.7	5.9		
Multi-ethnic	8.2	6.9	5.2	8.6	5.7	5.9		
Other	12.4	20.6	18.6	17.1	31.4	14.7		
EFL	71.1	70.3	77.9	67.6	71.4	75.8	[a]χ^2 (5) = 2.32	.803
Therapy	25.8	28.0	14.9	20.0	17.6	29.4	[a]χ^2 (5) = 6.86	.231
Medication	9.3	9.0	10.3	2.9	5.7	0.0	[a]χ^2 (5) = 5.63	.344

Note. MIP = mood induction procedure. EFL = English as first language. Therapy = history of therapy/counselling for an emotional or psychological problem. Medication = history of medication for an emotional or psychological problem.
[a]Analyses had insufficient cell sizes (expected count of less than 5), and results should therefore be interpreted with caution.

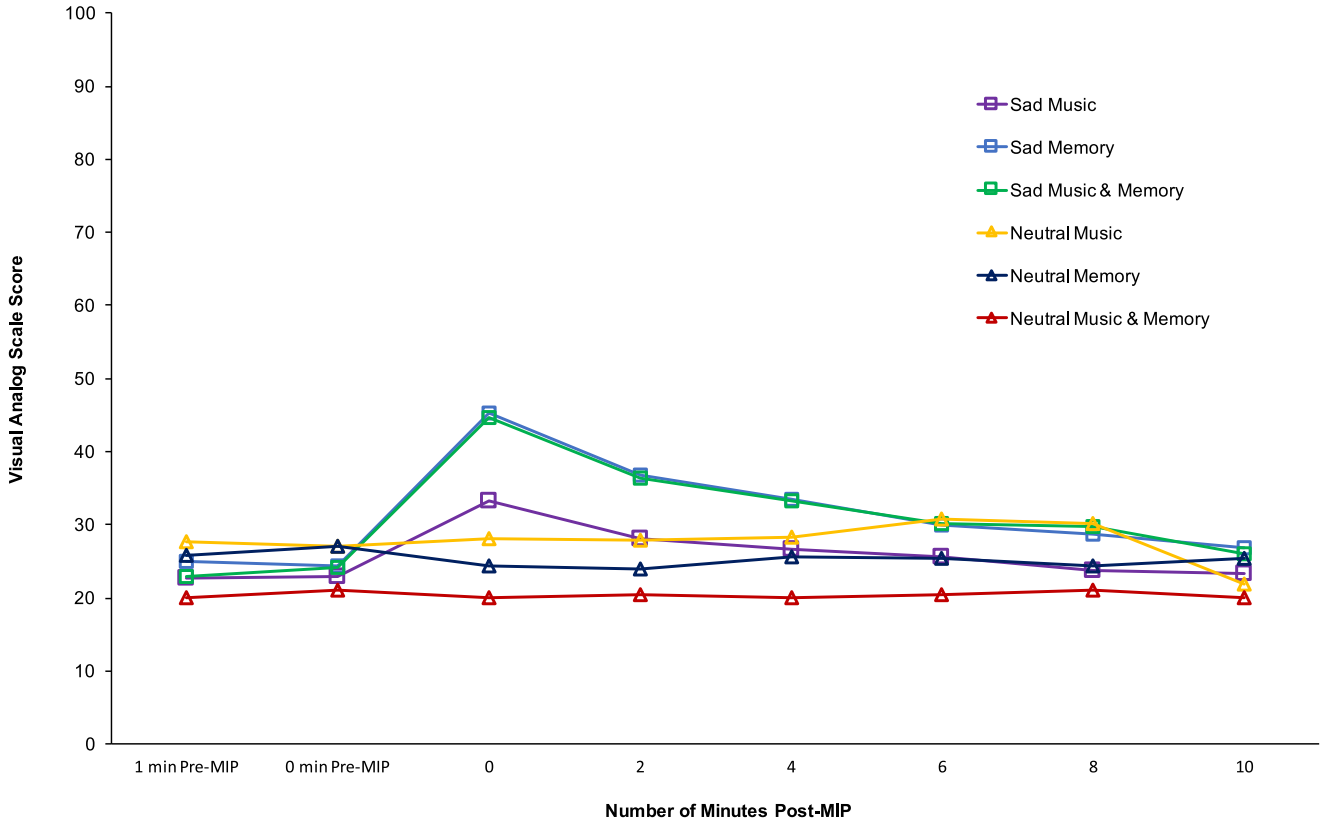

Fig. 1. Observed Visual Analog Scale (VAS) Score Group Means by MIP Condition
Note. Observed visual analog scale (VAS) score group means for each of the six MIP conditions at all 8 time points (i.e., at 1 min pre-MIP, immediately prior to the MIP, and at 0, 2, 4, 6, 8, and 10 min post-MIP.

Table 3
Time points post-MIP at which a sad mood is considered effectively induced, according to commonly used operational definitions.

Criterion	Minutes Post-MIP 0	2	4	6	8	10
Sad Music MIP						
Significant difference pre- vs. post-MIP	***	***	*			
Significant difference sad vs. neutral MIP	**					
Absolute change of ≥ 10 mm pre- to post-MIP						
Absolute change of ≥ 20 mm pre- to post-MIP						
Sad Memory MIP						
Significant difference pre- vs. post-MIP	***	***	***	***	**	*
Significant difference sad vs. neutral MIP	***	***	**			
Absolute change of ≥ 10 mm pre- to post-MIP						
Absolute change of ≥ 20 mm pre- to post-MIP						
Sad Music+Memory MIP						
Significant difference pre- vs. post-MIP	***	***	***	**	**	
Significant difference sad vs. neutral MIP	***	***	**			
Absolute change of ≥ 10 mm pre- to post-MIP						
Absolute change of ≥ 20 mm pre- to post-MIP						

Note. MIP = mood induction procedure. "Neutral MIP" refers to the combined sample of data from all three neutral MIP conditions (n = 104). Blue cells and red cells indicate whether the sad mood was considered induced (blue) or was not considered induced (red) according to the specific operational definition used at a particular time point. For criteria that relied on statistical significance, asterisks denote the p-value at which the test indicated a statistically significant difference.
*p < .05. ** p < .01. *** p < .001.

Table 4
Percentage of participants experiencing a successfully induced sad mood at each post-MIP time point, according to the operational definitions of at least a 10-mm and at least a 20-mm absolute change in mood pre- to post-MIP.

Condition	Minutes Post-MIP 0	2	4	6	8	10
	Absolute Change of ≥ 10 mm Pre- to Post-MIP					
	%	%	%	%	%	%
Music MIP (n = 97)	45	28	25	23	24	22
Memory MIP (n = 102)	69	50	36	27	27	23
Music+Memory MIP (n = 98)	71	48	41	36	34	27
	Absolute Change of ≥ 20 mm Pre- to Post-MIP					
Music MIP (n = 97)	23	12	10	11	10	14
Memory MIP (n = 102)	44	32	22	13	10	08
Music+Memory MIP (n = 98)	46	32	25	19	19	11

Note. MIP = mood induction procedure. The darkest blue cells indicate percentages ≥ 50 < 75; the medium blue cells indicate percentages ≥ 25 < 50; the lightest blue cell cells indicate percentages ≥ 0 < 25.

minimum pre- to post-MIP change value of 20 mm was used, 46% of participants would have been considered as displaying an effectively induced sad mood immediately following the MIP.

4. Discussion

A major untested assumption made by researchers studying cognitive vulnerability to depression is that MIPs commonly used in depression research induce sad moods that persist for the entirety of the tasks or measures of interest. To begin testing this assumption, this study aimed to determine how long an MIP-induced mood lasts, according to the most commonly used operational definitions of a successfully induced sad mood, and whether these findings vary according to the type of MIP used. The operational definitions included (1) a statistically significant change in mood pre- to post-MIP, (2) a statistically significant difference between the post-MIP mood scores of participants exposed to a control versus a sad MIP, and (3) a pre-determined absolute VAS change from pre- to post-MIP (either at the group or at the individual level).

The length of time for which a sad mood is considered to have been effectively induced following a sad MIP thus varies according to both the type of MIP used and the criterion used to operationally define an effectively induced sad mood. The wide variability in outcomes highlights how using differential operational definitions can result in different interpretations of findings. This supports the need for recognition of the impact that specific methodological and data analytic decisions have on the study outcomes.

Regardless of the MIP or operational definition used, however, the general finding is that MIP-induced sad moods may not persist for a sufficient amount of time for most participants to complete the tasks or measures that are frequently used in cognitive vulnerability research to assess the outcome variable of interest (i.e., 4 min; see Appendix G in Supplementary Materials). There can be no concrete determination of what length of time constitutes a "sufficiently persistent" mood effect, as

this will vary according to research questions and study design (e.g., the number and specific version of outcome measures used). Typically, however, commonly used measures of cognitive vulnerability, such as the DAS-A, an Implicit Association Task, or a Self-Referent-Encoding Task take more than 4 min to administer. For studies in which such tasks are used, the induced sad moods of music, memory, and music+memory MIPs would not be considered sufficiently persistent.

The results from this study are consistent with the findings from the only comparable study investigating temporal persistence of MIP-induced sad moods (Kuijsters et al., 2016), despite the fact that different MIPs and mood measures were used. Specifically, both studies found that induced sad moods rapidly began to dissipate within just a few minutes following the MIP, with moods no longer significantly different from baseline by about 6 minutes post-MIP (see Table 3).

Additionally, while many cognitive vulnerability researchers do not measure or report mood ratings more than once following the MIP, some do. For example, Lethbridge and Allen's (2008) study of mood-induced cognitive and emotional reactivity, life stress, and prediction of depressive relapse included two post-MIP measures of mood. The methodology of Lethbridge and Allen's study also very closely resembles that of the current study. Participants who were fully remitted from a previous episode of major depressive disorder completed the DAS items immediately before and after undergoing the same music+memory MIP used in the current study. Mood was measured on a 100-mm unipolar VAS pre- and post-MIP, as well as after completing DAS items.

Mean VAS sad mood scores from Lethbridge and Allen's study (2008) were estimated based on the figure presented in their article (p. 1146). Assuming it took participants in the Lethbridge and Allen study approximately the same amount of time it took participants in the current study to complete their DAS items, mean VAS scores from the Lethbridge and Allen study can be estimated as measures of sad mood pre-MIP, 0-min post-MIP, and 5-min post-MIP (see Appendix H in Supplementary Materials for a description of how time to complete DAS items was estimated). Fig. 2 shows both the observed trajectory of the sad mood effect of the music+memory MIP from the current study and the extrapolated trajectory of the sad mood effect from the Lethbridge and Allen study. As can be seen from Fig. 2, the trajectory from the current study and the estimated/extrapolated trajectory from the Lethbridge and Allen study are strikingly similar. Also notable is that the mean pre- and post-MIP sad mood scores observed in the current study are nearly identical to those in Lethbridge and Allen's. These similarities provide support for the robustness of the current study's findings.

4.1. Future directions

Given the general consistency of our findings with those of Kuijsters et al. (2016), as well as the striking similarity of our findings with those of Lethbridge and Allen (2008), there is support that the findings from the current study are not simply a chance occurrence. More research is needed, however, to ensure that these findings are robust and generalizable. For example, while the inclusion of three classes of sad MIPs commonly used in the research literature allows for greater generalizability to MIP research, it is important to note that there are additional classes of MIPs and that the specific methodologies even within MIP classes also vary widely. Film MIPs, in particular, have been used in more recent cognitive vulnerability research (LeMoult et al., 2016). Given the significant difference in the temporal persistence of the sad mood induced by the music MIP versus the memory and music+memory MIP observed in this study, it is possible that the temporal persistence of a film MIP-induced sad mood may also differ. Future studies should therefore replicate the current methodology, while extending it to include experimental conditions that include other classes of MIPs and variations in specific MIP methodological characteristics.

Furthermore, other factors not assessed in this study may have impacted the magnitude and persistence of MIP-induced sad mood effects, including the repeated measurement of mood (Torre and Lieberman, 2018) and the type of procedure or task completed in between mood measurements (Clasen et al., 2013). For example, labelling an emotion has been shown to activate implicit emotion regulation (Torre and Lieberman, 2018). It is thus possible that the repeated mood measurements following a sad MIP attenuated the induced sad mood effect through implicit emotion regulation. Future studies should extend the

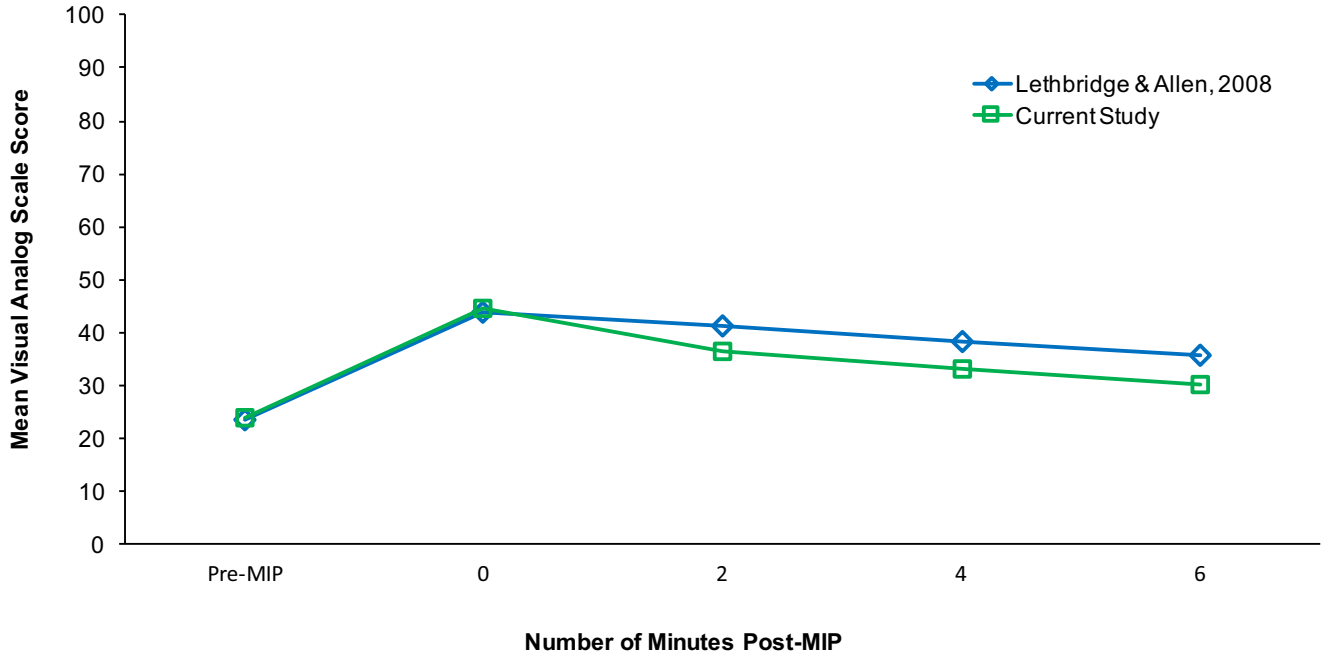

Fig. 2. Music+memory Participants' Mean Sad Mood Ratings and Estimated Mean Sad Mood Ratings from Lethbridge and Allen (2008)
Note. The observed mean sad mood ratings as measured by the visual analog scale (VAS) of participants in the music+memory condition in the current study are overlaid on the extrapolated mean VAS scores (estimated from Fig. 1 [p. 1146]) from Lethbridge and Allen (2008). Pre-MIP = VAS measurement immediately (0 min) prior to MIP administration.

current study design to assess for these effects, such as by using implicit measures of emotion, varied time intervals of mood measurements, and/or alternative measures of cognitive reactivity.

Additionally, the current study used data collected from an undergraduate student sample. MIP research is frequently conducted using such samples and non-vulnerable groups are often used in control conditions to compare to groups of vulnerable participants. However, theories of cognitive vulnerability to depression posit differential activation of negative cognitive structures in vulnerable versus non-vulnerable individuals. It is therefore possible that vulnerable and non-vulnerable individuals may display similar initial changes in sad mood, but that the induced sad mood may be more persistent in vulnerable individuals. Future studies should therefore include samples of vulnerable individuals (e.g., past depression) to determine whether the temporal persistence of MIP-induced sad moods differs based on this factor.

Moreover, future research is needed to explicitly clarify the degree of concordance between the trajectory of induced moods and the trajectory of cognitive reactivity to more confidently draw conclusions regarding the effectiveness of commonly used MIPs in cognitive vulnerability research (Scher et al., 2005).

Finally, the findings of this study indicate that one major and almost universally accepted assumption underlying sad MIP cognitive vulnerability research—that is, that an MIP-induced sad mood is sufficiently persistent—is likely not valid. Consequently, replication and extension studies will provide more definitive evidence as to the effectiveness or appropriateness of the use of MIPs in vulnerability research.

4.2. Implications

The results of this study constitute an important first step in validating the use of MIPs in cognitive vulnerability research and provide researchers with useful information regarding key study design decisions. For example, these study findings support the recommendation of using shorter measures of cognitive reactivity and additional measures of mood during and following the MIP (e.g., in between blocks of stimuli in a task). Doing so will allow investigators to document the persistence of an induced mood and note any substantial individual differences. Having these additional data will (1) contextualize the validity of the cognitive reactivity data and (2) allow participants who do not display a reasonably substantial and persistent sad mood to be excluded from analyses. The importance of implementing such methodological changes cannot be overstated: Results from studies in which researchers observe an apparent successfully induced sad mood but no resultant cognitive reactivity will likely remain unpublished. These lines of research are therefore more likely to remain uninvestigated. In the few cases in which a study with such findings is published, it is possible that the conclusions drawn from those results may not be entirely valid. As a result, it is possible that MIP research may be biased in such a way that our conceptualizations of cognitive vulnerability may, themselves, become misinformed or become distorted over time.

5. Conclusion

In summary, this study examined the major untested assumption that MIPs commonly used in depression research induce sad moods that persist for the entirety of the task or measure of interest. The results suggest two major findings: (1) MIP-induced sad moods do not persist for an amount of time that is sufficient for most participants to complete the tasks or measures that are frequently used in research to assess the outcome variable of interest; and (2) the length of time for which a sad mood is considered to have been effectively induced following a sad MIP varies according to both the type of MIP used and the criterion used to operationally define an effectively induced sad mood. This study therefore constitutes an important first step in validating the use of MIPs in cognitive vulnerability research and provides researchers with important information on how to design future studies. More important, the findings highlight the possibility that areas of research that rely heavily on MIP methodology may be biased by empirical findings predicated on untested assumptions.

Declarations of Competing Interest

None

Acknowledgement

The first author was supported by the Social Sciences and Humanities Research Council of Canada (SSHRC), and the second author was supported by an Insight Grant from SSHRC. Portions of these findings were presented as a poster at the 2018 International Congress of Applied Psychology, Palais des Congrès de Montréal, Montréal, QC, Canada. We have no conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2021.05.047.

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