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Clearing the Mind: A Working Memory Model of Distraction From Negative Mood

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The present research examined whether and how loading working memory can attenuate negative mood. In three experiments, participants were exposed to neutral, weakly negative, or strongly negative pictures followed by a task and a mood scale. Working memory demands were varied by manipulating task presence (Study 1), complexity (Study 2), and predictability (Study 3). Participants in all three experiments reported less negative moods in negative trials with high compared to low working memory demand. Working memory demands did not affect mood in the neutral trials. When working memory demands were high, participants no longer reported more negative moods in response to strongly negative pictures than to weakly negative pictures. These findings suggest that loading working memory prevents mood-congruent processing, and thereby promotes distraction from negative moods.

Keywords: mood regulation, distraction, working memory, affective intensity

Action seems to follow feeling, but really action and feeling go together; and by regulating the action, which is under the more direct control of the will, we can indirectly regulate the feeling, which is not.

William James (1899, p. 500)

One of James' important insights was that people's actions and feelings are closely intertwined. Although feelings often prompt subsequent actions, actions influence feelings as well. For example, when people feel frustrated after a long day at work, they may exercise at the gym in order to feel better (Byrne & Byrne, 1993). By studying outside of campus, students can prevent being lured into the thrills and pleasures of student life (Fishbach & Shah, 2006). And by foregoing practice when feeling uncertain about their performance, people can shield themselves against the disappointment of failure (Jones & Berglas, 1978; Tice, 1991).

In the present research, we highlight an additional way in which people's actions may regulate their feelings. More specifically, we investigate how actions that load working memory can distract people from their negative moods. In the following paragraphs, we begin by reviewing previous research on distraction from emotion. Next, we suggest that a key aspect of distraction is the use of limited processing capacity in working memory. The more working memory is being used by a distracting activity, the less room will remain for negative moods to persist. To test this notion, we present three experiments that analyzed the effectiveness of varying demands on working memory in distracting individuals from negative mood. Notably, the present research focused on the regulation of negative mood, because of its relevance to understanding mood disorders like chronic anxiety and depression

(Nolen-Hoeksema, 2000) and because regulation of negative mood has received most attention in the emotion regulation literature (Gross, 1998).

Distraction From Emotion

An act of distraction involves intentionally or unintentionally drawing one's attention away from a focal event. In the case of mood regulation, a distracting activity draws the person's attention away from his or her mood, so that the person's mood becomes more neutral. As such, the concept of distraction plays an important role in leading theories of emotion regulation (Bishop, Duncan, & Lawrence, 2004; Rusting & Nolen-Hoeksema, 1998; Trask & Sigmon, 1999).

Empirical research has confirmed that distraction can indeed have an important influence on people's moods. For example, depressed individuals who are distracted from their dysphoric mood states show alleviation of their depressive symptoms (Joormann & Siemer, 2004; Morrow & Nolen-Hoeksema, 1990). Likewise, angry individuals who are distracted show reduced anger (Gerin, Davidson, Christenfeld, Goyal, & Schwartz, 2006; Rusting & Nolen-Hoeksema, 1998). Distraction can also decrease individuals' cardiovascular responses to negative mood (Gerin et al., 1996; Glynn, Christenfeld, & Gerin, 2002).

Unfortunately, distraction may not always be that easy. People often find it difficult to distract themselves from their negative moods (Fiedler, Nickel, Asbeck, & Pagel, 2003; Josephson, Singer, & Salovey, 1996; Wegner, Erber, & Zanakos, 1993). Indeed, many individuals engage in prolonged negative ruminations when they would prefer to entertain more pleasant thoughts (Koole, Smeets, van Knippenberg, & Dijksterhuis, 1999; Kuhl, 1994; Martin & Tesser, 1996). These and other observations suggest that distraction involves more than simply turning one's attention elsewhere. Additional processes may be needed before distraction can be effective.

For distraction to be successful, people's feelings may need to be replaced by something else. In line with this idea, Morrow and

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Nolen-Hoeksema (1990) found that performing either motor movements (i.e., walking back and forth to sort giant cards) or a cognitive task both helped to distract participants from a previously induced depressive mood. However, the cognitive task was more effective than the motor movements in neutralizing participants' moods. To explain these findings, Morrow and Nolen-Hoeksema suggested that participants could still ruminate about their negative moods while they were moving about. Accordingly, the motor task might not have fully distracted participants from their mood states. By contrast, performing the cognitive task required participants to generate task-related thoughts that replaced mood-related thoughts. Thus, effective distraction may involve replacing emotionally charged thoughts with more neutral thoughts.

The differential effectiveness of various distracting activities was further explored by Erber and Tesser (1992). These investigators manipulated the amount of effort that participants invested in distracting activities, such as solving math equations. Task effort was manipulated by making investment in the task more or less motivationally relevant to participants, or by varying the complexity of the task. The results showed that distracting activities were more effective in neutralizing positive and negative moods to the extent that participants invested high rather than low effort in the distracting activity. Effortful cognitive activities are thus more distracting than other types of activities, presumably because effortful cognitive activities leave little room for mood states to persist.

A Working Memory Model of Distraction

Through which mechanisms might effortful cognitive activities prevent the continuation of negative moods? In the present article, we suggest that working memory is a likely candidate. Working memory is an assembly of structures and processes that is used for temporarily storing and manipulating information in memory (Baddeley, 1986). Because the capacity of working memory is limited, different activities compete over its resources. The more working memory capacity is used by one activity, the less can be used by another concurrent activity. We suggest that the same principle applies to mood-related processing. The more working memory a person needs to perform a distracter task, the less working memory will be left to maintain the person's current mood state.

Our working memory model of distraction from emotion assumes that mood-congruent cognitions are an integral part of the phenomenal experience of mood. This assumption has received strong empirical support: Negative affective states evoke mood-congruent cognitions (Blaney, 1986; Bower & Mayer, 1989; Siemer, 2005), even after the original stimulus that caused this state is no longer present (Bradley, Cuthbert, & Lang, 1996). People's cognitions thus often serve to sustain, and even intensify their initial negative affective response (Bradley et al., 1996; Nolen-Hoeksema, Morrow, & Fredrickson, 1993; Siegle, Steinhauer, Thase, Stenger, & Carter, 2002). Indeed, in a recent study, self-reported negative moods and mood-congruent cognitions were found to operate in a strictly parallel fashion (Siemer, 2005). The prevention of mood-congruent cognitions is thus a plausible mechanism that may underlie the effects of distraction.

This working memory account has important implications for understanding how different task demands may influence distraction from negative mood. First, any changes in task demands should distract from negative mood primarily to the extent that these task demands implicate working memory capacity. Second, the extent to which people use their working memory capacity can vary dynamically from moment to moment (Ashcraft & Kirk, 2001; Jostmann & Koole, 2006). It thus follows that dynamic changes in task demands can influence people's mood states on a moment-to-moment basis. Third, working memory capacity is a continuous variable, such that working memory can be used at low, medium, or high degrees (or take any intermediate value). Accordingly, a working memory account implies that varying task demands should have a linear effect on mood regulation. If a given task requires much working memory capacity, then distraction from negative mood should be relatively high. If a given task requires intermediate amounts of working memory capacity, then distraction from negative mood should be intermediate. If a given task requires low working memory capacity, then distraction from negative mood should be relatively low.

A more subtle but equally important implication of the present account involves the impact of task demands on processing of negative stimuli that vary in emotional intensity. Negative stimuli are generally more attention-grabbing than neutral or positive stimuli (Dolcos & McCarthy, 2006; Pratto & John, 1991). This processing advantage is stronger for strongly negative stimuli than for mildly negative stimuli (Schimmack, 2005). Strongly negative stimuli trigger more mood-congruent processing and, correspondingly, employ more working memory capacity than mildly negative stimuli (see Klein & Boals, 2001, for empirical evidence). A working memory account thus predicts an interaction between task demands and emotional intensity of negative stimuli. Distracter tasks that occupy working memory capacity may exert a greater influence on emotional processing of strongly rather than weakly negative stimuli.

The Present Research and Hypotheses

In the present research, we sought to test some of the predictions of the working memory model of distraction from negative mood. In three experiments, participants were presented with a series of neutral and negative pictures that varied in affective intensity. After viewing each picture, participants performed either a more or a less demanding task (or no task) and then reported their moods. Accordingly, the present research examined the role of distraction on moment-to-moment mood changes.

In Study 1, we investigated the effect of task presence and exposure to strong versus weak negative pictures on participants' moods. In line with a working memory model of distraction, we expected the intensity of negative mood reports to decrease when working memory load of a subsequent task would increase. Strongly negative pictures can be presumed to have a greater impact on working memory than mildly negative pictures (Schimmack, 2005). We therefore expected that a demanding task would attenuate participants' negative moods to a greater degree in response to strongly rather than mildly negative pictures.

Our main goal in Study 2 was to establish whether distraction depends on the amount of working memory capacity being used by the task, and not only on the redirection of attention away from the

affective stimulus and toward the task. To this end, we experimentally varied the complexity of the distracting task by having participants solve both simple and more complex equations. In this way, we manipulated the amount of information to be held in working memory. In addition, we wanted to replicate the interaction between task demands and emotional intensity of negative stimuli. We thus expected complex tasks to have a greater impact on further processing of strongly negative stimuli than on further processing of weakly negative stimuli.

In Study 3, we wanted to vary working memory load while keeping qualitative task parameters constant. Therefore, we varied working memory load by manipulating both the presence and the predictability of the math task. When a task is unpredictable, people cannot rely on already activated knowledge structures from long-term memory. Consequently, more working memory capacity has to be allocated to unpredictable tasks than to predictable tasks (Baddeley, Chincotta, & Adlam, 2001). We predicted a linear effect of working memory load on distraction from negative mood: The more working memory capacity is used to perform a task, the less is used for mood-related processing, and thus the more a previously induced mood should decrease. Predictable math tasks were hence expected to induce more distraction than no task, and unpredictable math tasks were expected to induce more distraction than predictable math tasks.

Study 1

Study 1 provided an initial investigation of the influence of working memory processes on moment-to-moment mood changes. Participants were presented with neutral or negative pictures, followed by either a math task or no task, upon which participants reported their moods. We expected participants to experience less intense negative moods in negative trials with a task, than in negative trials without a task. Moreover, because the math task was assumed to interfere with mood-congruent processing, we expected that the math task would not influence mood during neutral trials. Finally, we examined whether affective intensity and task presence would interact, as expected by a working memory account of distraction. We thus predicted that mood ratings after strongly negative pictures would be more attenuated by performing a distracting task than mood ratings after mildly negative pictures.

Method

Participants and design. Thirty-eight paid volunteers at the Vrije Universiteit van Amsterdam (12 men and 26 women; average age = 22 years) took part in the experiment. The experimental design was 2 (math task: no task vs. math task; within participants) \times 3 (picture negativity: neutral, mildly negative, or strongly negative; within participants). The main dependent variables consisted of participants' negative mood ratings and their math performance.

Procedure and equipment. Upon arrival in the laboratory, participants were led to individual cubicles with a personal computer. The experimenter explained that the remaining instructions would be administered via a computer-program and left. After a brief introduction and filling out some personality questionnaires, participants proceeded with a picture-viewing task. During this

task, participants were presented with either neutral or negative pictures. These pictures had been selected from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2001). Based on published normative valence ratings (ranging on a scale of 1 [most unpleasant] to 9 [most pleasant]), we selected two sets of 60 pictures, namely a negative set (valence ratings under 2.50) and a neutral set (valence ratings between 4.00 and 5.00). The negative pictures were further divided into two categories of either strong negative valence (30 pictures with normative IAPS scores lower than 2.2) or mild negative valence (30 pictures with normative IAPS scores of 2.2 and higher). In this way, we investigated whether the affective intensity of the pictures would differentially impact mood ratings in trials with, and without a task. Negative pictures included images of scenes with burn victims, physical assaults, and angry faces. Neutral pictures depicted scenes of people in conversation, scenes of nature or buildings, household objects, and neutral faces.

The picture viewing task consisted of 120 trials. During each trial, a negative or neutral picture appeared on screen for 4 seconds. During half of the trials, participants also had to solve a math task after viewing the picture. In between the picture and the math task, an announcement of the math task was displayed on the screen for one second. The math task consisted of a moderately complex equation, such as "2*8 + 12 = 28." Each equation combined a summation or subtraction with a product or a division. Participants judged whether the equation was correct by a keyboard response. Participants had 4 seconds to make this response. Both participants' responses and their response times were recorded. At the end of each trial, participants rated, with a keyboard response, how unpleasant they felt at that moment on a nine-point scale (1 = *not at all* to 9 = *very much*). In between trials, participants were asked to relax for 4 seconds. Before the 120 experimental trials, participants first received four practice trials to become familiar with the task. After the picture-viewing task, participants were thanked for their efforts, debriefed, and paid by the experimenter.

Results

Math performance. A 3 (picture negativity) analysis of variance (ANOVA) showed no effect of picture negativity on participants' correct responses, $F(2, 36) < 1$, or on participants' response times, $F(2, 36) = 1.76, ns$.

Mood. We only analyzed the correct trials (74%) to rule out possible influences of erroneous responding on participants' negative mood ratings. For instance, giving a wrong response might increase participants' negative moods. Throughout Studies 1–3, analyses of all trials or the incorrect trials did however not yield any differential results. Relevant means are displayed in Table 1.

To analyze participants moods, we conducted a 2 (task) \times 3 (picture negativity) ANOVA of participants' mood ratings. This analysis yielded a main effect of picture negativity: $F(2, 36) = 69.56, p < .001$. As expected, contrast analyses revealed a linear effect of picture negativity, $F(1, 37) = 134.52, p < .001$, such that participants reported most negative moods after strongly negative pictures ($M = 4.67$), less negative moods after mildly negative pictures ($M = 4.44$) and the least negative moods after neutral pictures ($M = 2.56$).

Table 1
Mean Negative Mood as a Function of Picture Negativity and Task (Study 1)

Task	Picture negativity		
	Neutral	Mild	Strong
Absent	2.58 _a (1.13)	4.82 _b (1.64)	5.32 _c (1.84)
Present	2.55 _a (1.17)	4.06 _a (1.47)	4.01 _a (1.59)

Note. *SD* in parentheses. Ratings ranged from 1 (*not at all*) to 9 (*very much*). Means that do not share subscripts differ within rows and columns at $p < .05$.

The ANOVA further yielded the predicted interaction between task and picture negativity, $F(2, 36) = 28.60, p < .001$. We proceeded by analyzing the effect of task separately for each picture negativity condition. Analysis of the neutral pictures yielded no effect of task, $F(1, 37) = 1.21, ns$. We therefore focused our further analyses solely on the negative trials. In the negative trials, the analyses produced an effect of task for both the strongly negative, as well as the mildly negative trials ($F(1, 37) = 60.35, p < .001$ and $F(1, 37) = 38.92, p < .001$, respectively). These effects indicate that, across both strongly and mildly negative trials, participants reported less negative moods in negative trials with a task, than in negative trials without a task.

Another valid way to interpret the picture negativity by task interaction in the negative trials is to consider the effect of picture negativity separately for each task condition. This analysis yielded an effect for picture negativity in the negative trials without a task $F(1, 37) = 28.45, p < .001$. In these trials, participants reported significantly less intense negative moods following mildly negative pictures ($M = 4.83$) than following strongly negative pictures ($M = 5.32$). There was, however, no effect of picture negativity on negative mood in trials with a task, $F(1, 37) = .13, ns$. ($M = 4.01$ and $M = 4.07$, respectively for mildly vs. strongly negative pictures). Thus, strongly negative pictures only elicited more negative moods than mildly negative pictures in trials without a math task. In trials with a math task, strongly and weakly negative pictures induced equal amounts of negative mood.

Discussion

The results of Study 1 showed the predicted effects of task presence on moment-to moment ratings of negative mood. In line with a working memory model, participants reported less negative moods after negative pictures followed by a math task than when negative pictures were not followed by a task. Performing a math task did not influence participants' moods during neutral trials. Also in line with a working memory model, performing a math task interacted with the intensity of the negative pictures. Specifically, participants' moods after strongly negative pictures were more attenuated by performing a math task than moods after mildly negative pictures. Indeed, when a task was present, mood ratings after strongly negative pictures no longer differed from mood ratings after mildly negative pictures. This is in line with the idea that strongly negative pictures have a greater impact on working memory capacity than mildly negative pictures, so that

the processing of these pictures should be affected more by additional working memory demands.

Study 2

Although the results of Study 1 fit with a working memory model of distraction, Study 1 only manipulated the presence or absence of a demanding task. As such, it is hard to say whether the effects of task presence on negative mood resulted from variations in processing capacity, as our analysis suggests, or whether these effects resulted merely from an attentional shift away from the current mood state. We conducted Study 2 to address this ambiguity.

In Study 2, participants solved a math equation in each trial. To vary involvement of working memory, we manipulated task complexity during the different trials. In half of the trials, neutral and negative pictures were followed by the same math equations as in Study 1. In the remaining trials, pictures were followed by much simpler equations. Previous research has found that complex math tasks make greater demands on working memory capacity than simple math tasks (Ashcraft, Donley, Halas & Vakali, 1992). Thus, if the effects of the math tasks in Study 1 were due to their differential demands on working memory capacity, distraction from negative moods should be greater after performing complex rather than simple math tasks. On the other hand, if the results of Study 1 were due mainly to a shift in attention away from the negative mood state, performing complex and simple math tasks should induce similar levels of distraction from negative moods.

Study 2 again examined whether picture negativity and task presence would interact. As in Study 1, we predicted that mood ratings after strongly negative pictures would be more attenuated by task complexity than mood ratings after mildly negative pictures.

Method

Participants and design. Thirty-nine paid volunteers at the Vrije Universiteit van Amsterdam (7 men and 32 women; average age = 20 years) took part in the experiment. The experimental design was 2 (task complexity: simple vs. complex) \times 3 (picture negativity: neutral, mildly negative, or strongly negative), both factors within participants. The main dependent variables consisted of participants' negative mood ratings and their math performance.

Procedure and equipment. The procedure of Study 2 was similar to Study 1. Participants again performed the picture-viewing task. This time, all pictures were followed by a math task. The complexity of the math task was varied experimentally. In half of the trials, the math task consisted of an equation similar to the moderately complex equations used in Study 1, such as "2*8 + 12 = 28." Each of these equations always combined a summation or subtraction with a product or a division. In the remaining trials, the math task consisted of a much simpler equation, such as "7 + 2 = 9." Each of these equations only consisted of either a summation or a subtraction.

Results

Math performance. A 2 (task complexity) \times 3 (picture negativity) ANOVA revealed a main effect for task complexity, $F(1,$

Table 2
Mean Negative Mood as a Function of Picture Negativity and Task Complexity (Study 2)

Task	Picture negativity		
	Neutral	Mild	Strong
Simple	2.61 _a (1.00)	4.16 _b (1.26)	4.71 _c (1.43)
Complex	2.66 _a (1.12)	3.97 _{bd} (1.31)	3.92 _d (1.38)

Note. SD in parentheses. Ratings ranged from 1 (*not at all*) to 9 (*very much*). Means that do not share subscripts differ within rows and columns at $p < .05$.

38) = 234.41, $p < .001$. This effect can be seen as a manipulation check. Participants performed better on the simple math trials than on the complex math trials ($M = 96\%$ correct vs. $M = 70\%$ correct), irrespective of picture negativity. Participants were also faster on the simple math equations than on the complex math equations, $F(1, 38) = 1770.78$, $p < .001$ ($M = 1932$ vs. $M = 3021$).

Negative mood. We analyzed negative mood ratings in a 2 (task complexity) \times 3 (picture negativity) ANOVA. Relevant means are displayed in Table 2. In this analysis, we again only used affect ratings of the correctly answered math-trials (83% of all responses). The analysis revealed a main effect of picture negativity on participants' mood ratings: $F(2, 37) = 52.05$, $p < .001$. As expected, contrast analyses revealed a linear effect of picture negativity, $F(1, 37) = 134.52$, $p < .001$, such that participants reported most negative moods after strongly negative pictures ($M = 4.67$), less negative moods after mildly negative pictures ($M = 4.44$), and the least negative moods after neutral pictures ($M = 2.56$).

The ANOVA further yielded the predicted interaction between task complexity and picture negativity, $F(2, 37) = 13.62$, $p < .001$. We again did not find an effect of task complexity in the neutral trials, $F < 1$. To better understand the interaction, we proceeded by analyzing the negative trials (mildly vs. strongly negative). We first analyzed the effects of task complexity separately in each negativity condition. These analyses did not yield a significant effect of task complexity in the mildly negative trials, $F(1, 38) = 2.64$, *ns*. Nevertheless, at a descriptive level, participants did report less negative moods in response to mildly negative pictures followed by a complex task ($M = 3.97$) rather than a simple task ($M = 4.16$). By contrast, the analyses revealed a highly significant effect for task complexity in the strongly negative trials, $F(1, 38) = 29.13$, $p < .001$. Participants reported less negative moods after strongly negative pictures followed by a complex math equation rather than a simple math equation ($M = 3.92$ vs. $M = 4.71$).

As in Study 1, we then considered the effect of picture negativity (mildly vs. strongly negative) separately for each task condition. In the negative trials with a simple task, the analysis yielded an effect for picture valence, $F(1, 38) = 21.05$, $p < .001$. In trials containing a simple task, participants reported more negative moods following strongly negative pictures than following mildly negative pictures ($M = 4.71$ vs. $M = 4.16$). By contrast, in negative trials with a complex task, there was no effect of picture valence on participants' negative moods, $F(1, 38) < 1$. In trials

containing a complex task, participants reported as much negative mood in response to strongly negative pictures as in response to mildly negative pictures ($M = 3.97$ vs. $M = 3.92$).

Recall that we found an effect of task complexity on participants' response times. To rule out that differences in task duration could explain the effect of task complexity on negative mood ratings in the negative trials, we therefore repeated our analyses with participant's response time difference between the complex and the simple trials as a covariate. A 2 (task complexity) analysis of covariance (ANCOVA) analysis of the negative mood ratings in the negative trials still revealed a strong effect for task complexity, $F(1, 38) = 27.07$, $p < .001$. Moreover, when entered as a covariate, response time differences were unable to account for the effects of task complexity on negative moods, $F(1, 37) < 1$.

Discussion

The results of Study 2 replicate and extend Study 1. Because each trial now contained a math task, we could investigate the impact of varying working memory load on negative mood. In line with predictions, participants reported less negative moods after strongly negative pictures followed by a complex task than after strongly negative pictures followed by a simple task. Participants also reported somewhat less negative moods in response to mildly negative pictures followed by a complex rather than a simple task. However, the latter effect of task load did not reach statistical significance. Thus, while an increase in task load resulted in a decrease in mood ratings across both strongly and mildly negative pictures, this decrease was much smaller for mildly negative pictures. This is in line with the assumption that an increase in working memory load should have a greater impact on additional processing of strongly negative stimuli than on additional processing of weakly negative stimuli. These findings thus further support our working memory model of distraction from negative mood.

A possible confound in Studies 1 and 2, however, was task duration. As the results showed, participants took less time to solve simple equations than to solve complex equations. Although the effects of task complexity remained unchanged when we statistically controlled for this difference, we cannot rule out the possibility that qualitative differences between the two types of equations, other than their complexity, impacted participants' moods. This problem could not simply be resolved by using shorter timeframes, because doing so might make the complex task too difficult, and thereby undermine participants' motivation to invest effort in the task. We therefore took another approach in Study 3 to address this problem.

Study 3

In Study 3, we varied the predictability of the complex math task that was used as a distraction, while keeping all other task parameters constant. Unannounced or novel stimuli make greater demands on central executive resources, and thus on working memory (Baddeley et al., 2001; Spector & Biederman, 1976). In this regard, it is important to note that, in our experiments, participants had limited time (4 seconds) to perform the math task. Even though one can argue that in absolute terms, announced and unannounced math tasks require the same amount of working memory, announced math tasks entail working memory earlier, but

more evenly distributed over time. Unannounced math tasks under a time limit on the other hand, “pull up” all required working memory at once, thus making a much greater demand on total WM capacity at one moment. Unexpected tasks should hence be more potent distracters from negative mood than expected tasks. An important advantage of this approach was that, because the actual task was always the same, this ruled out possible confounding factors due to qualitative differences between tasks.

Another advantage of varying task predictability was that we could examine the linearity of the effect of task load on negative mood. We manipulated task predictability by randomly presenting trials without a task, trials with an announced task, and with a sudden task. On the basis of our working memory model of distraction from negative mood, we expected participants to report least negative moods in the negative trials with a sudden task (high load), intermediate negative moods in the negative trials with an announced task (intermediate load), and most negative moods in negative trials without a task (no load).

Finally, as in Studies 1 and 2, we predicted that higher task load would interfere especially with the further processing of strongly negative pictures. We therefore expected that strongly negative pictures would induce more negative moods than mildly negative pictures especially in trials where working memory load was low, or absent, such as in the trials with the announced task or no task. By contrast, we predicted that strongly negative pictures would induce equally negative moods as mildly negative pictures in trials where working memory load was high, such as in the trials with the sudden math task.

Method

Participants and design. Forty paid volunteers at the Vrije Universiteit van Amsterdam (12 men and 28 women; average age = 20 years) took part in the experiment. The experimental design was 3 (task type: sudden, announced, or no task) \times 3 (picture negativity: neutral, mildly negative, and strongly negative), both within participants. The main dependent variables consisted of participants’ math performance and their negative affect ratings.

Procedure and equipment. The procedure was similar as in Studies 1 and 2. This time, one third of the neutral and negative pictures were followed by a sudden math task, one third by an announced math task, while the remaining pictures were not followed by a math task. To announce the math task, the word “som,” which is Dutch for “calculation,” was displayed on screen one second before the task appeared. In this way, we experimentally varied the predictability of the math task. The math task following two thirds of the pictures consisted of equations similar to the equations used in Study 1 and the complex equations used in Study 2.

Results

Math performance. A 3 (task type) \times 3 (picture negativity) ANOVA revealed a main effect for task type on math performance, $F(2, 38) = 40.98, p < .001$. Participants gave more correct responses in the announced math trials than in the unannounced math trials ($M = 73\%$; $M = 65\%$). The analyses revealed no effect for task type on response times. Thus, participants solved the announced math tasks equally quickly as the unannounced math tasks, $F(2, 38) = 1.55, ns$, ($M = 2,474$ vs. $M = 2,534$, respectively).

Table 3
Mean Negative Mood as a Function of Picture Negativity and Task Type (Study 3)

Task Type	Picture negativity		
	Neutral	Mild	Strong
No task	3.09 _a (1.55)	4.78 _b (1.73)	5.35 _d (1.94)
Announced task	2.88 _a (1.32)	4.52 _c (1.83)	5.12 _c (1.94)
Sudden task	2.92 _a (1.27)	4.26 _f (1.70)	4.40 _f (1.73)

Note. SD in parentheses. Ratings ranged from 1 (*not at all*) to 9 (*very much*). Means that do not share subscripts differ within rows and columns at $p < .05$.

Negative mood. We analyzed participants’ negative mood ratings in a 3 (task type) \times 3 (picture negativity) ANOVA for repeated measures. In this analysis, we again only used affect ratings of the correctly answered math-trials (79% of all responses). Relevant means are displayed in Table 3. The analysis yielded a main effect for picture negativity: $F(2, 38) = 70.40, p < .001$. The analysis further yielded the expected interaction between picture negativity and task type, $F(4, 36) = 4.26, p < .01$.

In order to understand these effects, we proceeded by analyzing the effect of picture negativity and task type separately using linear contrast analyses. As in Studies 1 and 2, these analyses yielded a linear effect for picture negativity, $F(1, 39) = 125.46, p < .001$. Participants reported more negative moods after strongly negative pictures than after mildly negative pictures ($M = 4.96$ vs. $M = 4.52$) and least negative moods after neutral pictures ($M = 2.94$).

Furthermore, in line with our predictions, there was a linear effect for task type for both the strongly negative, as well as the mildly negative trials ($F(1, 39) = 19.46, p < .001$ and $F(1, 39) = 33.19, p < .001$, respectively). Thus, participants’ negative moods linearly decreased as working memory load increased, irrespective of the intensity of the negative pictures. As in Studies 1 and 2, we did not find a linear effect for task type on the mood ratings in the neutral trials ($F(1, 39) = 2.01, ns$). Accordingly, we restricted our further analyses exclusively to the negative trials.

Next, we considered the effect of picture negativity (mildly vs. strongly negative) separately by task type. This analysis revealed a significant effect for picture negativity on the negative mood ratings in trials containing an announced task, $F(1, 39) = 21.30, p < .001$, and trials without a task, $F(1, 39) = 29.40, p < .001$. By contrast, there was no effect for picture negativity on the mood ratings in the trials containing the unannounced task, $F(1, 39) < 1$. Thus, when trials contained an announced task, or no task, participants reported significantly less negative mood after mildly negative pictures ($M = 4.52$ vs. $M = 4.78$ for announced, and no tasks respectively) than after strongly negative pictures ($M = 5.12$ vs. $M = 5.35$ for announced, and no tasks respectively). In negative trials with an unannounced task, however, participants’ negative moods after strongly negative pictures ($M = 4.40$) did not differ significantly from their moods after mildly negative pictures ($M = 4.26$).

Discussion

In Study 3, we manipulated working memory load by varying task predictability, while the actual task was always the same.

In this way, Study 3 controlled for qualitative differences between tasks such as duration. As expected, working memory load had a linear effect on participants' negative mood ratings. Participants reported more negative moods after negative pictures without a subsequent task (no load) than after negative pictures followed by an announced task (intermediate load), while they reported even less negative moods in trials with an unannounced task (high load). Moreover, in the trials with a sudden math task, participants reported as much negative moods after strongly negative pictures as after mildly negative pictures. In the trials with an announced math task or no task, participants reported more negative moods after strongly negative pictures than after mildly negative pictures. Apparently, when task load was high, strongly negative pictures no longer elicited more mood-related processing than mildly negative pictures.

General Discussion

In the present research, we proposed that people can distract themselves from negative moods by loading their working memory capacity. In line with this model, three experiments showed that variations in working memory load moderate the impact of viewing negative pictures on mood. Participants reported less negative moods after viewing negative pictures when they had to solve complex math problems rather than no math problems (Study 1) or simple math problems (Study 2). The moderating effect of math problems on negative mood was stronger for unannounced math problems, which presumably use more working memory capacity (Spector & Biederman, 1976), than for announced math problems (Study 3). Solving math problems had no effect on mood after participants viewed neutral pictures (Studies 1–3). Finally, solving math problems had a stronger moderating impact on negative mood when participants had viewed strongly rather than mildly negative pictures (Studies 1–3). The latter findings fit well with a working memory model, given that strongly negative stimuli use greater working memory capacity than mildly negative stimuli (Schimmack, 2005).

The present studies show that distraction from negative mood involves more than simply redirecting one's attention away from the emotional stimulus. However, we do not mean to say that attention is irrelevant to distraction from negative mood. Processes of selective attention are critical for the operation of working memory (Baddeley & Hitch, 1974; Engle, Tuholski, Laughlin, & Conway, 1999). This can be illustrated by the way we manipulated working memory in our research, namely by varying the complexity or the predictability of a distracter task. When performing a simple or predictable task, people can rely on more habitual processes, such that attention can still shift to mood-related information. When people are confronted with a more complex, or unexpected task, however, people can no longer rely on habitual processes, but instead need to focus their full attention on the task (Baddeley, 1998; Norman & Shallice, 1980).

The present findings fit well with neuropsychological findings about the interaction of higher cognitive mechanisms for attention and controlled processing with (lower limbic) regions involved in emotional processing (Cohen, Lohr, Paul, & Boland, 2001;

Drevets & Raichle, 1998; Mayberg et al., 1999). For example, participants, when they had to judge emotional pictures on some nonvalenced criteria, namely picture format, displayed less involvement of limbic regions while watching the affective pictures, than when they had to judge the pictures' valence, or had to indicate if the pictures evoked any feelings (Northoff et al., 2004). Increased involvement of the cognitive system may thus lead to a decreased involvement of the emotional system (Hariri, Bookheimer, & Mazziotta, 2000; Northoff et al., 2004), and vice versa (Bishop et al., 2004; Dolcos & McCarthy, 2006; Mitchell, Richell, Leonard, & Blair, 2006).

It is informative to compare distraction with suppression of emotional thoughts, another well-established emotion regulation strategy (Roemer & Borkovec, 1994; Wenzlaff, Wegner & Roper, 1988). In both strategies, people alter their emotional states by preventing emotion-related cognitions to enter awareness. However, during emotional thought suppression, the active inhibition of emotional thoughts may actually make emotion-related material more accessible (Howell & Conway, 1992; Wenzlaff et al., 1988), resulting in mood rebounds (Wegner et al., 1993; Wenzlaff & Luxton, 2003). Because distraction does not require the active suppression of emotional thoughts, it should not result in mood rebounds. In support of this, research has shown that when people were distracted following a negative mood induction, subsequent rumination did not again deteriorate their moods. When people however ruminated immediately after the negative mood induction, their negative mood states persisted (Trask & Sigmon, 1999).

Although distraction seems a relatively efficient emotion regulation strategy, it may not necessarily be the most optimal approach under all circumstances. First, for a distracter task to be effective, it should not elicit negative feelings by itself. Ashcraft and Kirk (2001), for example, demonstrated that people high on math-anxiety performed more poorly on a math task than people low on math anxiety, because anxious thoughts incorporated working memory capacity and thus interfered with efficient task performance. For people high on math anxiety then, the math task no longer functioned as a neutral cognitive distracter, but as a negative affective stimulus in itself, producing negative feelings instead of replacing them with neutral thoughts. Low emotionality of the distracter task is therefore an important boundary condition for distraction from negative mood.

Second, distraction may not be the most effective way to resolve more structural causes of negative mood, such as for example problematic relationships, or difficulties at work. This is because distraction leaves the source of the negative emotion itself intact. In highly distressing situations, it may be helpful to distract oneself initially, in order to step back and put things in perspective. In the end, however, distraction is no substitute for problem solving. For example, workaholics often explain their excessive work habits by stating that it helps them forget about problems in their private life (Robinson, 2001). At the same time, there exists an inverse relationship between marital satisfaction and obsessive working in the research literature (Matthews, Conger, & Wickrama, 1996; Robinson, 2001). In these and related instances, distraction from negative mood may actually contribute to a vicious cycle of maladaptive behavior. Identifying the costs and benefits of distraction from negative mood clearly constitutes an important task for future research.

Limitations and Future Perspectives

The present research demonstrates how increasing working memory load of a distracter task may attenuate negative mood. It is not clear however, whether the model also applies to distraction from positive mood. Recent studies in our lab, using a similar paradigm as the present studies, failed to find an effect of working memory load on positive mood (Van Dillen & Koole, 2006; though see Erber & Tesser, 1992). As such, distraction from positive mood may not operate according to the same principles as distraction from negative mood. It is conceivable that positive emotional stimuli may impact cognitive processes through a different route than negative emotional stimuli (Isen, 2002). For example, positive emotional states do not always result in mood-congruent processing (Fiedler et al., 2003), and can increase both cognitive flexibility (Baumann & Kuhl, 2005), as well as distractibility (Dreisbach & Goschke, 2004). Clearly, the question how distraction from positive mood may operate deserves more attention in future research.

Although the present research demonstrated that distraction can attenuate negative moods in response to negative pictures, distracted participants still reported less negative moods in response to neutral pictures. Physiological responses to emotional stimuli take several minutes to return to baseline, even when people are distracted (Glynn et al., 2002). These physiological responses may thus continue to impact participants' negative mood after four seconds, the interval we used between the picture display and the mood scale. Extending this interval from several seconds to several minutes may effectively reduce negative mood to neutral levels. In line with this, Erber and Tesser (1992) found a complete neutralization of negative mood when participants solved moderately complex math equations for 10 minutes after the mood induction. The exact relationship between the duration and the effectiveness of distraction from negative moods represents a fruitful topic for future inquiry.

Future work is also needed to clarify the effects of type of working memory load on distraction from emotion. Baddeley and colleagues (Baddeley & Hitch, 1974) proposed that working memory consisted of two storage buffers (the phonological loop for verbal information and the visuospatial sketchpad for nonverbal information), which are assumed to be relatively independent. For example, anxiety has been shown to have a disproportionate effect on verbal working memory while leaving visuospatial working memory performance (implicated in nonverbal working memory) unaffected (Ikeda, Iwanaga, & Seiwa, 1996). Thus, verbalization of mood-related information seems to interfere particularly with verbal working memory (Gray, 2001). Further research should address whether a distracter task that implicates a different working memory device than mood-related processing still results in attenuation of negative moods.

Concluding Remarks

In everyday life, the effectiveness of distraction from negative mood is widely recognized, given that people are often advised to "move on" when in a negative state by seeking out alternative activities. Nevertheless, distraction is typically used as an explanatory construct rather than as a phenomenon that needs to be explained. In the present research, we sought to deepen our un-

derstanding of the underlying mechanisms of distraction from negative mood by proposing a working memory model. By loading working memory, people can attenuate the impact of negative events on their moods. Thus, in keeping with William James' early observations on the close interplay between actions and feelings, the present research highlights distraction as one important type of action through which people may regulate their feelings.

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