Sadness Increases Distraction by Auditory Deviant Stimuli

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Research shows that attention is ineluctably captured away from a focal visual task by rare and unexpected changes (deviants) in an otherwise repeated stream of task-irrelevant auditory distractors (standards). The fundamental cognitive mechanisms underlying this effect have been the object of an increasing number of studies but their sensitivity to mood and emotions remains relatively unexplored despite suggestion of greater distractibility in negative emotional contexts. In this study, we examined the effect of sadness, a widespread form of emotional distress and a symptom of many disorders, on distraction by deviant sounds. Participants received either a sadness induction or a neutral mood induction by means of a mixed procedure based on music and autobiographical recall prior to taking part in an auditory-visual oddball task in which they categorized visual digits while ignoring task-irrelevant sounds. The results showed that although all participants exhibited significantly longer response times in the visual categorization task following the presentation of rare and unexpected deviant sounds relative to that of the standard sound, this distraction effect was significantly greater in participants who had received the sadness induction (a twofold increase). The residual distraction on the subsequent trial (postdeviance distraction) was equivalent in both groups, suggesting that sadness interfered with the disengagement of attention from the deviant sound and back toward the target stimulus. We propose that this disengagement impairment reflected the monopolization of cognitive resources by sadness and/or associated ruminations. Our findings suggest that sadness can increase distraction even when distractors are emotionally neutral.

Keywords: deviance distraction, auditory-visual oddball task, deviant sounds, sadness, mood induction

Efficient cognitive functioning requires an optimum balance between the ability to screen out extraneous stimuli that might interfere with our performance and, on the other hand, the capability of detecting unexpected stimuli that may be of some relevance outside the scope of the task at hand. The latter has been shown to be underpinned by specific neural and cognitive mechanisms able to capture attention and orient it toward stimuli that deviate from our expectations in order to be evaluated (e.g., Parmentier, 2008). Although the adaptive advantage of possessing such mechanisms is important, these come at a cost, namely distraction in the task at hand. This type of distraction has been reliably examined in the laboratory and recent studies have shed light on the electrophysiological and cognitive mechanisms underpinning it, with an almost exclusive focus on the role of stimuli and task characteristics. In comparison, participant characteristics have received relatively less interest. Their emotional state, in particular, has seldom been studied despite widespread evidence of the intricate links between emotion and cognition (e.g., Bower, 1981; Forgas, 2008) and evidence that emotions influence the way we perceive and attend information from our direct environment and adapt our actions to it (see Dolan, 2002; Pessoa, 2008, for reviews). The issue is particularly interesting when considering that some have suggested that one adaptive reaction to sadness is to seek distraction to take our mind off sad thoughts in order to help restore a neutral or positive mood (e.g., Gross, 1998; Lazarus, 1991). A natural prediction, yet not addressed to date, is that participants feeling sad should exhibit enhanced distraction by task irrelevant distractors in a controlled laboratory task. Our study aimed to test this prediction. We begin by outlining some evidence of the impact of sadness on cognition, defining deviance distraction and the evidence suggesting that negative emotions increase distraction.

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Sadness and Its Effects on Cognition

Sadness is one of the most widespread forms of emotional distress and a symptom involved in many disorders (such as eating, bipolar or personality disorders) and particularly salient in depression where it is persistent. In comparison to other emo-

tions such as fear and anxiety, the impact of sadness on cognition remains largely unexplored (Chepenik, Cornew, & Farah, 2007). Most studies examining the issue, whether in healthy or in depressed individuals, have commonly focused on its negative effects on memory (see Bower, 1981; Williams, Watts, MacLeod, & Mathews, 1997, for reviews), the processing facilitation enjoyed by negative stimuli or the delay they yield in withdrawing from them (e.g., Wisco, Treat, & Hollingworth, 2012). Importantly, such research has heavily relied on tasks involving emotionally loaded stimuli.

In contrast, the effect of sadness on fundamental attentional mechanisms as measured by emotionally neutral stimuli remains unclear even though some have suggested that one natural way to cope with sadness is to reduce one's resistance to distraction (e.g., Gross, 1998; Lazarus, 1991). Distraction and the drawing of attention away from sad thoughts is also an important part of the cognitive therapy treatment of depression where patients have difficulties in stopping rumination (i.e., McRae et al., 2010; Nolen-hoeksema & Morrow, 1993; Van Dillen & Koole, 2007). Finally, in more general terms, sadness is thought to motivate one to process the information in a vigilant and detail-oriented manner possibly in order to reestablish a sense of control over the situation (e.g., Bodenhausen, Gabriel, & Lineberger, 2000; Forgas, 1995; Gasper, 2004; Schwarz & Clore, 1996).

Distraction by Deviant Sounds

Electrophysiological studies have established that unexpected changes in a repetitive or otherwise structured auditory sequence typically yield three specific and automatic brain responses (e.g., Berti, 2008; Berti, Roeber, & Schröger, 2004; Schröger, 1996, 1997, 2005, 2007; Schröger & Wolff, 1998): mismatch negativity (MMN, Näätänen, 1990; Näätänen, Paavilainen, Rinne, & Alho, 2007), P3a (e.g., Escera, Alho, Winkler, & Näätänen, 1998), and the reorientation negativity (RON; e.g., Berti & Schröger, 2001). The MMN response is most often interpreted as an indicator of the detection of a mismatch between an incoming sound and the neural trace of past sounds (e.g., Näätänen, 1990) or the detection of a violation of expectations (e.g., Schröger, Bendixen, Trujillo-Barreto, & Roeber, 2007; Winkler, 2007). The P3a and RON responses are typically interpreted respectively as the involuntary orientation of attention toward the deviant or novel stimulus, and the reorientation of attention toward the primary task including the reactivation of relevant task sets in working memory. Of interest in this study, sounds deviating from a repetitive background (henceforth referred to as deviants) also yield behavioral distraction (see Parmentier, 2013, for a review), typically by delaying responses to target stimuli in a primary task (e.g., Schröger, 1996), such as when participants must judge the duration of tones in the face of rare irrelevant changes in pitch (e.g., Berti & Schröger, 2003, 2004) or where participants are asked to categorize visual stimuli while ignoring auditory distractors presented immediately before each target (Andrés, Parmentier, & Escera, 2006; Escera et al., 1998; Parmentier, 2008; Parmentier, Elsley, & Ljungberg, 2010; Parmentier & Hebrero, 2013; Parmentier, Maybery, & Elsley, 2010; Parmentier, Turner, & Perez, 2013; see also Parmentier, Ljungberg, Elsley, & Lindkvist, 2011, for converging evidence with tactile distractors). Deviance distraction results from the time penalty associated with the orientation of attention to and from the deviant stimulus (Parmentier, Elford, Escera, Andrés, & San-Miguel, 2008) when these are unexpected (Parmentier, Elsley, Andrés, & Barceló, 2011), and can be exacerbated by a conflict between the involuntary processing of the deviant sounds' content and the voluntary processing of the target stimulus (Parmentier, 2008; Parmentier, Turner, & Elsley, 2011; Parmentier et al., 2013).

Deviance distraction invokes both stimuli-driven and top-down processes. For example, the fast and involuntary capture of attention by deviant stimuli marked by MMN and the orientation of attention to them reflected by P3a are sensitive to perceptual properties of the deviant sounds (e.g., Schröger, 1996). The later component RON, on the other hand, has been interpreted as reflecting top-down mechanisms relating to working memory (Munka & Berti, 2006) responsible for refocusing attention on the task at hand (Roeber, Berti, & Schröger, 2003; Roeber, Widmann, & Schröger, 2003) and the reactivating task sets within working memory in preparation for the next trial (Berti, 2008). Interestingly, the RON component is also observed on the first standard trial following a deviant trial (Roeber, Berti, & Schröger, 2003; Roeber, Widmann, & Schröger, 2003), as is some residual behavioral distraction referred to as postdeviant distraction (Parmentier & Andrés, 2010; Roeber et al., 2005; Roeber, Berti, & Schröger, 2003; Roeber, Widmann, & Schröger, 2003). Parmentier and Andrés (2010) proposed that deviant distraction may involve both bottom-up and top-down contributions and postdeviance distraction may mostly involve the completion of the task set reconfiguration in a way evoking the residual cost observed on the first trial after a task switch (Rogers & Monsell, 1995). This description ties in well with Corbetta and Shulman's model of attention (Corbetta & Shulman, 2002; see also Corbetta, Patel, & Shulman, 2008) in which two systems work together in order to deal with stimuli in our immediate environment: the first automatic and triggered by the detection of unexpected or salient stimuli, the second responsible for the volitional selection of sensory information and responses based on prior knowledge, expectations or current task goals (see Debener, Kranczioch, Herrmann, & Engel, 2002; Strobel et al., 2008, for neurological evidence of the distinction between these two systems). Postdeviance distraction is regarded as reflecting the completion, on the first trial following a deviant trial, of a task set reconfiguration initiated in that deviant trial. Thus, it is related to deviance distraction but the latter involves a number of additional processes (orientation to the deviant, reorientation of attention from it, reactivation of the relevant task set; Parmentier & Andrés, 2010). In sum, deviance distraction combines top-down as well as bottom-up processes and postdeviance distraction is hypothesized to involve some of the latter.

Deviance Distraction and Emotional Context

Several studies have shown that emotionally salient or biologically relevant stimuli (i.e., fearful faces, snakes) are particularly prone to capture attention, even in conditions where attention resources are limited (for reviews, see Compton, 2003; Dolan, 2002; Dolcos, Iordan, & Dolcos, 2011; Vuilleumier, 2005; Yiend, 2010). Such stimuli have typically been used as target or distractors stimuli (Campanella et al., 2002; Delplanque, Silvert, Hot, & Sequeira, 2005). More recently, some studies using the cross-modal oddball task used negative pictures to create emotional contexts (Domínguez-Borràs, Garcia-Garcia, & Escera, 2008;

Domínguez-Borràs et al., 2009; Garcia-Garcia, Yordanova, Kolev, Domínguez-Borràs, & Escera, 2010; Lv, Wang, Tu, Zheng, & Qiu, 2011). Their results show that participants asked to categorize visual targets do so more slowly following the unexpected presentation of a novel sound compared with a standard tone. More importantly, they show that this distraction increases when the sounds are presented in the negative emotional context. However, these studies present some limitations. First, they assume that the presentation of pictures evokes emotions but include no independent measurements of emotions. Second, these studies remain noncommittal regarding the specific emotions supposedly manipulated because the pictures they used in the negative context condition may arguably have produced anxiety, stress, arousal, fear, disgust, and/or sadness. Third, their mixed presentation of negative and neutral trials makes it unlikely that participants were in an entirely neutral or negative emotional state at any given time. This might have led to underestimate the impact of the emotional context and might possibly explain why the negative context increased distraction in some studies but did not in others (Garcia-Garcia, Clemente, Domínguez-Borràs, & Escera, 2010; Garcia-Garcia, Domínguez-Borràs, SanMiguel, & Escera, 2008).

Our Study and Hypotheses

We report an experiment in which we manipulated the participants' emotional state (neutral vs. sad) by way of an induction method before they performed a cross-modal oddball task using emotional neutral stimuli. Based on suggestions that sadness elicits greater propensity to process distracting information (e.g., Bodenhausen et al., 2000; Forgas, 1995; Gasper, 2004; Schwarz & Clore, 1996) and that negative emotions appear to increase deviance distraction (Domínguez-Borràs et al., 2008; Domínguez-Borràs et al., 2009; Garcia-Garcia, Yordanova, et al., 2010), our prediction was that participants in the sadness induction group would exhibit greater deviance distraction. In addition, we also assessed postdeviance distraction with the aim to explore whether sadness may have differential effects on bottom-up and top-down contributors to distraction (under the assumption that postdeviance distraction is a purer manifestation of task-set reactivation than deviance distraction; Parmentier & Andrés, 2010). This was exploratory in part but also motivated by the suggestion that emotional states (as opposed to traits) appear to enhance bottom-up rather than top-down attentional networks (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). If so, our secondary prediction would be that sadness should increase deviance distraction more than postdeviance distraction (or possibly affect the first and not the second).

Method

Participants

Forty undergraduate students aged 17–32 ($M = 20.50$ years, $SD = 2.90$; 37 females) participated. All participants reported normal or corrected-to-normal vision and hearing, and were naïve to the purpose of the experiment. All received a small honorarium in exchange for their participation in the study. This study was approved by the ethical committee of the Department of Psychology at the University of the Balearic Islands.

Mood Induction Procedure (MIP)

To induce sad and neutral emotional states, we used an experimental MIP combining music and autobiographical recall (see Martin, 1990 for a review of the effectiveness of these methods). Instructions about the autobiographical recall were presented on a computer screen and the music via headphones.

In the sadness-MIP condition, participants were presented with written instructions on the computer screen. These required participants to recall, as vividly as possible, the saddest event that had occurred in their life. They were encouraged to carefully remember and evoke details about that situation, how they felt, what their thoughts were at the time, and to try to immerse into the mood of that moment as deeply as possible. Participants reminisced about this sad event for 4 minutes, after which they were instructed to write down on a sheet of paper as detailed a description of the event as possible. This writing phase lasted 5 minutes. Throughout the induction, musical pieces were played through the participants' headphones. These pieces (*Adagio for Strings, Op.11* by Samuel Barber, and *5th Symphony Adagietto* by Mahler) were selected for their propensity to induce sadness as reported in earlier work (Chepenik et al., 2007; Niedenthal & Setterlund, 1994; Riener, Stefanucci, Proffitt, & Clore, 2011; Robinson, Cools, Crockett, & Sahakian, 2010; Schmid & Schmid Mast, 2010; Storbeck & Clore, 2005).

In the neutral-MIP condition, the procedure was identical to that of the sadness-MIP condition with the difference that participants were asked to remember a recent trip to the grocery shop. They were encouraged to recollect details of the shop, their localization, and their actions in that shop. Participants in this condition were exposed to musical pieces (*The Planets, Op. 32: VII. Neptune, the Mystic* by Gustav Holst and the Largo movement from *New World Symphony* by Antonin Dvorak) selected for their emotional neutrality (Au Yeung, Dalgleish, Golden, & Schartau, 2006; Berna et al., 2010; Robinson et al., 2010; Schmid & Schmid Mast, 2010).

Mood and Music Assessment

To ascertain that our MIPs were effective, we used the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988; Spanish version: Sandín et al., 1999). This test includes 20 emotional words or adjectives that participants must rate from 1 (*very slightly*) to 5 (*extremely*) in order to reflect the degree to which each reflects their current state. The 20 items divide into two 10-item subscales, one measuring positive affect (PANAS-PA), the other measuring negative affect (PANAS-NA). We also used the *Scale for Mood Assessment* (EVEA; Sanz, 2001), which measures the participant's state of anxiety, sadness, anger, and happiness. This scale includes 16 items (four adjectives for the four aforementioned states), each evaluated using a Likert scale (ranging from 0 to 10). Additionally, we designed a self-rating scale, the Scale for Specific Emotions (SSE) to specifically measure the participants' level of sadness, as well as six other emotions (anger, disgust, fear, anxiety, happiness, and surprise). As in the EVEA, participants were asked to score each emotion using a Likert scale (ranging from 0 to 10).

Finally, the Self-Assessment Mannequin test (SAM; Lang, 1980) was used to assess the participants' affective reactions to the music played during mood induction. This test consists of three 5-point bipolar scales that indicate emotional reactions along each

of three emotions: pleasure from 1 (*pleasant*) to 5 (*unpleasant*); arousal from 1 (*calm*) to 5 (*excited*); and dominance from 1 (*controlled*) to 5 (*dominant*).

Oddball Task

Two 200 ms long sounds were used throughout the experiment. The standard sound was a 600 Hz sine-wave tone. The deviant sound was a burst of white noise. Both sounds were normalized and digitally edited to include 10 ms rise and fall ramps. Sounds were delivered binaurally through headphones at an intensity of approximately 70 dB(A).

As illustrated in Figure 1, each trial involved the presentation of a sound followed by a visual digit (in white color against a black screen) with a sound-to-digits stimulus onset asynchrony of 250 ms. Digits appeared for 200 ms at the center of the screen and sustained an angle of approximately 2.6°, temporarily replacing the fixation crossed otherwise always visible at the center of the screen. Upon the digit's offset, the fixation cross reappeared for 600 ms during which participants were required to press a key to categorize each digit as odd or even as quickly as possible while trying to make no error. The experiment took place in a sound attenuated room and took approximately 1 hr to complete.

Participants completed four blocks of 180 test trials each. In each block the digits 1 to 6 were used equally often in each of the two sound conditions (standard, deviant). The standard sound was used in 80% of trials, and the deviant sound in the remaining 20%, arranged in a random sequence (different for every participant and block) with the constraint that deviant sounds were never presented on subsequent trials. Participants categorized the digits as odd or even using the V and B keys on the computer keyboard (the mapping of key to response being counterbalanced across participants). Each block was preceded by 12 practice standard trials that were not included in the data analysis.

Procedure

Participants were randomly assigned to the neutral and sadness induction conditions on arrival at the laboratory and informed consent was obtained from all of them before the experiment began. Each participant was provided with a booklet containing all the questionnaires and an information page describing the two phases of the study: the induction phase (excluding information about the specific mood that would be induced) and the oddball task. Participants were encouraged to respond sincerely and truthfully to the questionnaires.

Participants filled out the PANAS, the EVEA, and the SSE twice and with the explicit instruction to indicate how they felt at that moment: before and after the mood induction. After filling out the set of questionnaires for the first time, they were instructed to put the headphones on and follow instructions appearing on the screen in order to begin the mood induction phase while listening to musical pieces. The music pieces played throughout the induction and completion of the postinduction questionnaires. Participants were then administered with the oddball task. Finally, the music was turned off and participants proceeded to run the oddball task. Upon completion of the latter, they completed the EVEA again, as well as the SAM to evaluate the musical pieces presented throughout the MIP.

Finally, all participants, upon completing the experiment and before being debriefed, were exposed to *Eine Kleine Nachtmusik* by Mozart, a musical piece that has been effectively used in previous studies to induce a positive mood (i.e., Niedenthal & Setterlund, 1994; Riener et al., 2011; Schmid & Schmid Mast, 2010; Storbeck & Clore, 2005), with instructions to relax and enjoy the music to facilitate return to a baseline euthymic mood.

Results

The results are broken down in three parts. We first report analyses of the mood questionnaires in order to ascertain the efficiency and validity of our mood induction conditions. We limit our report to the key measures of relevance for our study (results for secondary measures are reported in the Appendix). Second, we report data measuring the participants' emotional response to the musical pieces used in our study. Finally, we analyzed the data from the oddball task in order to assess whether auditory distraction differed as a function of the mood induction condition.
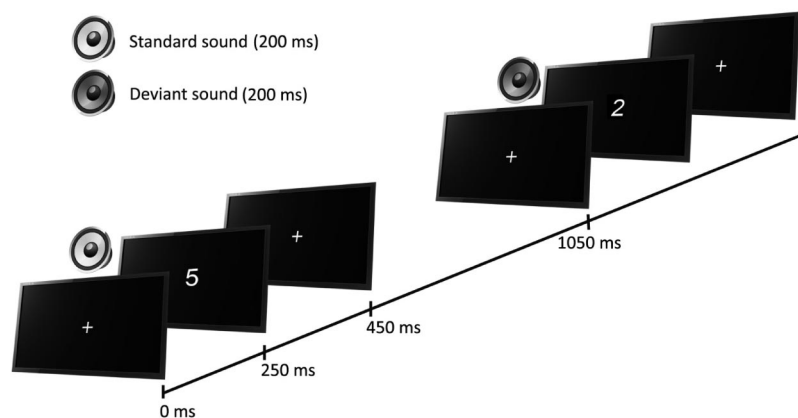

Figure 1. Schematic illustration of the cross-modal oddball task in which each trial started with the presentation of 200 ms auditory distractor that participants were instructed to ignore, followed by a 200 ms visual digit they categorized as odd or even before the next trial began 600 ms later.

Effects of MIP on Mood

In the recall-writing task of the sadness mood induction group, 17 participants reported the death of a loved one (relatives or close friends) through accident or to a terminal illness, two participants reported the loss of their pet, and one recalled his or her parents' divorce. In the neutral mood induction group, none of the participants reported details about any incident or event that could be considered especially positive or negative; instead, they were all neutral.

PANAS-PA scores, shown in Table 1, measured before and after the mood induction were analyzed using a 2 (Group: sadness, neutral induction) $\times$ 2 (Time: before, after induction) mixed ANOVA. The main effects of group, $F(1, 38) = 9.12$, $MSE = 42.92$, $p = .004$, $\eta_p^2 = .19$, and time, $F(1, 38) = 4.70$, $MSE = 19.19$, $p = .036$, $\eta_p^2 = .11$, were significant, as was the interaction between these variables, $F(1, 38) = 16.46$, $MSE = 19.19$, $p < .001$, $\eta_p^2 = .30$. As expected, the two groups did not differ from each other before induction ($F < 1$). Following induction, however, positive affective scores were significantly lower in the sadness mood induction group than in the neutral group, $F(1, 38) = 17.56$, $MSE = 40.17$, $p < .001$, $\eta_p^2 = .31$. The same analysis performed on the PANAS-NA scores revealed significant main effects of group, $F(1, 38) = 5.20$, $MSE = 28.51$, $p = .028$, $\eta_p^2 = .12$, and time, $F(1, 38) = 5.58$, $MSE = 16.16$, $p = .023$, $\eta_p^2 = .13$. Importantly, the group $\times$ time interaction was also significant, $F(1, 38) = 20.04$, $MSE = 16.16$, $p < .001$, $\eta_p^2 = .34$. Prelevel scores did not differ between the group prior to the mood induction ($F < 1$), but did so following it: negative affective scores were significantly higher in the sadness mood induction group relative to the neutral group, $F(1, 38) = 16.74$, $MSE = 27.21$, $p < .001$, $\eta_p^2 = .30$.

The same analyses were conducted for sad and neutral scores of the SSE. The sadness mood subscale revealed main effects of group, $F(1, 38) = 13.63$, $MSE = 6.31$, $p < .001$, $\eta_p^2 = .26$, and time, $F(1, 38) = 44.01$, $MSE = 3.49$, $p < .001$, $\eta_p^2 = .53$. The group $\times$ time interaction was also significant, $F(1, 38) = 69.01$, $MSE = 3.49$, $p < .001$, $\eta_p^2 = .64$, showing that the sadness mood induction group produced significantly lower scores than the neutral group before induction, $F(1, 38) = 5.46$, $MSE = 3.58$, $p = .025$, $\eta_p^2 = .12$, but greater scores following induction, $F(1, 38) = 49.44$, $MSE = 6.23$, $p < .001$, $\eta_p^2 = .56$. For the neutral mood subscale, the main effect of group was not significant ($F < 1$), but the main effect of time was, $F(1, 38) = 18.12$, $MSE = 6.48$, $p < .001$, $\eta_p^2 = .32$. The group $\times$ time interaction was marginally

significant, $F(1, 38) = 3.90$, $MSE = 6.48$, $p = .056$, $\eta_p^2 = .09$: Groups did not differ in prelevel scores ($F < 1$), but the neutral mood induction group reported significantly higher scores than the sadness group in postinduction measures, $F(1, 38) = 4.60$, $MSE = 7.03$, $p = .038$, $\eta_p^2 = .10$.

A 2 (Group: sadness, neutral induction) $\times$ 3 (Time: before induction, after induction, after the oddball task) ANOVA performed on the ratings from the sadness subscale of EVEA yielded significant main effects of group, $F(1, 38) = 12.89$, $MSE = 8.14$, $p < .001$, $\eta_p^2 = .25$, and time, $F(2, 76) = 25.44$, $MSE = 1.74$, $p < .001$, $\eta_p^2 = .40$. The interaction between these variables was also significant, $F(2, 76) = 29.04$, $MSE = 1.74$, $p < .001$, $\eta_p^2 = .43$. Scores were similar for the two groups before induction ($F < 1$), but were significantly higher in the sadness mood induction group, both following completion of the induction phase and of the oddball task, $F(1, 38) = 41.60$, $MSE = 4.04$, $p < .001$, $\eta_p^2 = .52$; and $F(1, 38) = 9.05$, $MSE = 4.03$, $p < .005$, $\eta_p^2 = .19$, respectively.

In summary, our mood manipulation was effective in inducing sadness in the sadness induction group and in that group only, and in eliciting effects strong enough to last through the completion of the oddball task.

Music Assessment

An ANOVA performed on SAM valence ratings revealed significant differences between the groups in their emotional reaction to the musical pieces, $F(1, 38) = 57.00$, $MSE = .77$, $p < .001$, $\eta_p^2 = .60$. The songs presented to the sadness induction group were rated as significantly more unpleasant than those presented to the neutral group ($M = 4.3$, $SD = .65$, vs. $M = 2.2$, $SD = 1.05$, respectively). The neutral and sad pieces did not differ with respect to dominance ratings, $F(1, 38) = 1.56$, $MSE = 1.02$, $p = .218$, $\eta_p^2 = .03$ ($M = 3.0$, $SD = .91$, vs. $M = 2.6$, $SD = 1.09$), or in terms of induced arousal ($F < 1$; $M = 2.5$, $SD = 1.10$, vs. $M = 2.3$, $SD = 1.13$, respectively).

Oddball Task Performance

Data analysis. The mean proportion of correct responses and mean response latencies for correct responses were analyzed using 2 (sadness, neutral mood induction, between participants) $\times$ 3 (trial type: standard, deviant, and postdeviant standard, within-participant) ANOVA.

Proportion correct. A significant main effect of trial type was found, $F(2, 76) = 6.17$, $MSE = .001$, $p < .005$, $\eta_p^2 = .13$ (see

Table 1
Means and Standard Deviations (in Parentheses), in the PANAS, Sadness Subscale of the EVEA, and the Sadness and Neutral Subscales of the SSE for the Different Mood Groups

	PANAS-PA	PANAS-NA	EVEA-Sadness	SSE-Sadness	SSE-Neutral
Sadness mood induction					
Pre MIP	30.95 (4.86)	15.05 (2.98)	2.03 (1.53)	0.85 (0.98)	5.75 (3.32)
Post MIP	24.85 (6.43)	21.20 (5.51)	6.25 (2.24)	7.10 (2.97)	2.20 (2.44)
Final			3.51 (2.42)		
Neutral mood induction					
Pre MIP	31.40 (4.50)	16.35 (5.10)	2.43 (2.17)	2.25 (2.48)	5.30 (3.02)
Post MIP	33.25 (6.23)	14.45 (4.90)	2.15 (1.74)	1.55 (1.90)	4.00 (2.84)
Final			1.60 (1.48)		

Figure 2, top panel). Participants responded significantly more accurately in standard sound than in deviant sound trials, $F(1, 38) = 10.37$, $MSE = .001$, $p < .005$, $\eta_p^2 = .21$, and in postdeviant standard sound than in deviant sound trials, $F(1, 38) = 6.30$, $MSE = .002$, $p = .016$, $\eta_p^2 = .14$. No difference in accuracy was found between standard and postdeviant standard sounds ($F < 1$). The main effect of group was not significant, and neither was the group × sound interaction (both $Fs < 1$).

Response latencies for correct responses. The analysis of response latencies revealed a main effect of trial type, $F(2, 76) = 39.20$, $MSE = 291$, $p < .001$, $\eta_p^2 = .50$ (see Figure 2). As expected, participants were slower in deviant trials compared with standard (deviance distraction) or postdeviant standard trials, $F(1, 38) = 55.74$, $MSE = 406$, $p < .001$, $\eta_p^2 = .59$; and $F(1, 38) = 24.23$, $MSE = 311$, $p < .001$, $\eta_p^2 = .38$, respectively. Response were also slower in postdeviant standard trials than in the standard trials (postdeviance distraction), $F(1, 38) = 25.99$, $MSE = 156$, $p < .001$, $\eta_p^2 = .40$. The main effect of group was not significant, $F(1, 38) = 2.83$, $MSE = 9988$, $p = .100$, $\eta_p^2 = .06$. Most critically, however, the group × sound condition interaction was significant, $F(2, 76) = 4.90$, $MSE = 291$, $p < .01$, $\eta_p^2 = .11$. Further analyses were carried out to compare the two groups with respect to deviance distraction (reaction time [RT] deviant–RT standard) and postdeviance distraction (RT postdeviant standard–RT standard). Deviance distraction was larger in the sadness induction group compared to the neutral group ($M = 45.26$, $SD = 33.90$, and $M = 22.01$, $SD = 21.79$), $F(1, 38) = 6.66$, $MSE = 812$, $p = .013$, $\eta_p^2 = .15$. In contrast, the two groups showed similar levels of postdeviance distraction ($M = 17.69$, $SD = 19.34$, and $M = 10.77$, $SD = 15.79$), $F(1, 38) = 1.53$, $MSE = 311$, $p = .222$, $\eta_p^2 = .03$. In order to assess whether sadness slowed response times independently of distraction, a contrast was carried out comparing the two groups in the standard condition. Although RTs were numerically faster in the neutral group than in the sadness induction group ($M = 487.68$, $SD = 51.32$, and $M = 507.35$, $SD = 60.61$, respectively), this difference was not significant, $F(1, 38) = 1,355$, $MSE = 3154$, $p = .251$, $\eta_p^2 = .034$. Finally, we examined whether deviance distraction correlated with the participants' level of sadness (as measured by the sadness component of the EVEA immediately before the oddball task): This correlation was significant, $r = .35$, $p = .027$. In sum, deviance and postdeviance distraction were observed in both groups but deviance distraction was significantly greater in the sadness induction group.
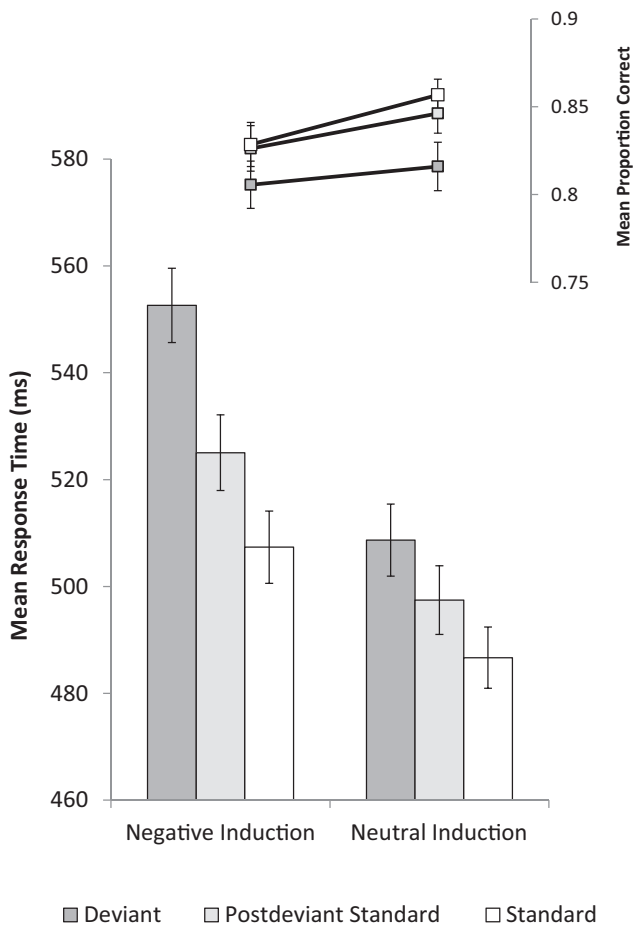
Discussion

This study reported the first attempt to measure the effect of induced sadness on deviance and postdeviance distraction in a cross-modal oddball task in which target and distractor stimuli were not emotionally loaded. A number of key results were found. First, data from our questionnaire measures corroborate that our induction manipulation was effective and induced sadness in the sadness induction group and not in the neutral group. Furthermore, they also showed that this effect was relatively specific (e.g., the sadness induction, although unsurprisingly increasing anger and hostility, did not affect state anxiety, disgust, surprise or fear). Second, the questionnaire measures also indicated that the effect of the sadness induction persisted across the duration of the experiment and, most critically, the cross-modal oddball task. These findings confirm that asking participants to recollect and write about personal live events while listening to music constitutes an effec-

tive induction method, in line with other studies' findings using the same induction procedures (i.e., Berna et al., 2010; Chepenik et al., 2007; Niedenthal & Setterlund, 1994; Riener et al., 2011; Robinson et al., 2010; Storbeck & Clore, 2005). Third, and most importantly, deviance distraction was significantly greater (twofold increase) following the induction of sadness, as compared with participants in the neutral induction group. Although participants in the sadness induction group were numerically but not significantly slower than participants in the neutral group, the finding of a significant increase in distraction suggests that sadness affected the orienting to and disengagement from the deviant sounds more than the mere processing of the target stimuli.

Remarkably, the increase in distraction due to sadness was observed in a task involving neutral stimuli, suggesting that sadness affects fundamental attention mechanisms and enhances participants' sensitivity to changes in their immediate environment and/or disrupting the disengagement of attention from task-irrelevant stimuli. This aspect is worth emphasizing because most

Figure 2. Performance in the cross-modal oddball task as a function of the induction condition (negative, neutral) and the sound condition (deviant, postdeviant standard, standard). Error bars represent one standard error of the mean.

previous studies examining the role of emotion in attention capture by novel stimuli have involved emotionally loaded tasks (Campanella et al., 2002; Delplanque et al., 2005; Domínguez-Borràs et al., 2008, 2009; Ischebeck, Endrass, Simon, & Kathmann, 2011; Karl, Malta, Maercker, 2006; Kemp et al., 2010; Lv et al., 2011; Wang, LaBar, & McCarthy, 2006), making difficult the distinction between the emotional and sensory/perceptual effects of such stimuli. Our results clearly indicate that mood state may be an important moderator of distraction by deviant stimuli even when these stimuli do not convey any emotional content per se and are not associated with any specific emotional response.

The greater vulnerability to distractors elicited by sadness can be explained by the latter's adaptive function, namely to signal that the current situation is problematic and promote a more vigilant and systematic appraisal of the external environment (Bodenhausen et al., 2000; Forgas, 2007; Gasper, 2004; Schwarz & Clore, 1996). Interestingly, sadness affected deviance distraction but not postdeviance distraction, suggesting that sadness may affect specific processes involved in deviance distraction (orientation to and from the deviant, reactivation of the relevant task set) more than the completion of the task-set reconfiguration thought to reflect postdeviance distraction (e.g., Berti, 2008; Munka & Berti, 2006; Parmentier & Andrés, 2010). This finding contrasts with the increase of both effects with aging (Parmentier & Andrés, 2010), suggesting that postdeviance distraction, although related to deviance distraction, does not necessarily increase with the latter. We suggest that sadness might exert its effect at two possible levels. First, it may affect bottom-up processing by relaxing attentional filters and thereby facilitating the intrusion of deviant distractors into the focus of attention. Such view fits with the proposition that negative mood affects bottom-up processes rather than top-down control (e.g., Bishop, Jenkins, & Lawrence, 2007; Eysenck, Derakshan, Santos, & Calvo, 2007; Pacheco-Unguetti et al., 2010). Second, sadness may disrupt the disengagement of attention away from the deviant distractor and the reorientation of attention to the target stimulus. Both of these aspects relate directly to the presentation of the deviant sound and thereby to deviance distraction, not postdeviance distraction.

One potential explanation of our findings is that participants in the sadness induction group may have experienced ruminating thoughts while performing the cross-modal oddball task or that sadness consumed general cognitive resources (Watkins & Brown, 2002). The numerical slowing of responses in the sadness group compared with the neutral is compatible with this hypothesis. Ruminations may have acted as a mental load and, as such, affected the orienting response toward the deviant sound and the attention disengagement from it and toward the target stimulus. Past work measuring the impact of a mental load on deviance distraction showed that such a factor does not enhance but, instead, reduces behavioral distraction and the P3a response to deviant sounds (Berti & Schröger, 2003; Parmentier et al., 2008, Experiment 2). Hence, the increase of distraction yielded by sadness in our experiment is unlikely to reflect the disruption of the orienting response to the deviant sound. Instead, it is most likely to reflect a difficulty in disengaging from the deviant sound to reorient attention toward the target stimulus. We argue that sadness and ruminations consumed resources that would otherwise have been devoted to the top-down disengagement of attention from the deviant sound, in line with the notion that rumination disrupts attentional

disengagement (Koster, De Lissnyder, Derakshan, & De Raedt, 2011). Evidence also indicates that a negative emotional state reduces the ability to remove negative information from one's working memory (e.g., Berman et al., 2011; Brinker, Campisi, Gibbs, & Izzard, 2013; Whitmer & Banich, 2007). One remarkable aspect of our results is that, although the majority of studies on attention and emotion observe a slower disengagement from negative visual stimuli (e.g., Calvo, Guitiérrez, & Fernández-Martín, 2012; Fox, Russo, & Dutton, 2002; Sanchez, Vazquez, Marker, LeMoult, & Joormann, 2013), we observed a difficulty in disengaging from the deviant sounds that were emotionally neutral. This leads to two possible and nonmutually exclusive propositions. The first is that sadness may disrupt fundamental mechanisms of attentional disengagement regardless of the distractors' emotional valence on the basis of a depletion of general cognitive resources. The second is that this disengagement impairment may be the by-product of attentional resources being monopolized by the rumination of negative thoughts. This distinction may be of theoretical importance and should be the object of future work.

The dissociation we observed between deviant and postdeviance distraction may have important implications for studies investigating distraction in specific clinical populations. Our study is, as far we are aware, the first to identify a factor affecting deviance distraction independently of postdeviance distraction. For comparison, cognitive aging increases both (Parmentier & Andres, 2010). At a minimum, our results suggest that future studies should measure both types of distraction in an attempt to better refine our understanding of how certain conditions affect attentional mechanisms. It is possible that mood states, specific personality characteristics, affective disorders or other types of conditions that increase deviance distraction (e.g., Gumenyuk et al., 2005; Jääskeläinen et al., 1996) may do so in distinct in ways that may only become more visible by systematically contrasting deviance and postdeviance distraction. Such dissociation has proven useful in the study of other concepts such as that of anxiety. For example, high trait-anxiety has been related to an impairment of top-down control processes, whereas high state-anxiety appears to be more associated with an alteration of bottom-up control processes (Pacheco-Unguetti et al., 2010). Pathological anxiety, in contrast, has been shown to involve deficits of both bottom-up and top-down processes (Pacheco-Unguetti, Acosta, Marqués, & Lupiáñez, 2011). It is worth noting that our results cannot be accounted for by assuming that inducing sadness increased state anxiety thereby affecting the bottom-up processing of distractors because our measures of state anxiety showed no significant differences between groups and did not increase before and after the induction.

To sum up, our study provides the first demonstration of the effect of induced sadness on distraction by task-irrelevant and emotionally neutral deviant sounds. We suggest that this effect is likely to reflect a difficulty in disengaging from the attention-capturing deviant distractors because of the depletion of attentional resources by sadness and/or accompanying ruminations. Our results suggest that distractors need not be negative for distraction to be amplified by sadness and open new avenues of research to understand how mood affects fundamental attentional mechanisms.

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(*Appendix follows*)

Appendix

Results From the Secondary Mood Questionnaires

	SSE-Anxiety	SSE-Disgust	SSE-Fear	SSE-Surprise	SSE-Anger	SSE-Happiness	EVEA-Anxiety	EVEA-Hostility	EVEA-Happiness
Sadness mood induction									
Pre MIP	1.45 (1.60)	0.10 (0.30)	0.75 (1.29)	2.75 (3.00)	0.20 (0.61)	6.20 (1.54)	2.81 (1.72)	0.77 (0.98)	6.00 (1.60)
Post MIP	2.95 (2.30)	0.25 (0.63)	1.80 (1.85)	2.05 (2.81)	0.80 (1.73)	2.35 (2.47)	3.53 (2.17)	1.78 (1.79)	2.31 (1.99)
Final							4.57 (2.44)	2.48 (2.60)	3.67 (2.19)
Neutral mood induction									
Post MIP	2.10 (2.31)	0.00 (0.00)	0.60 (1.60)	3.40 (3.48)	0.45 (0.99)	6.30 (2.90)	2.25 (2.00)	0.76 (0.83)	5.86 (2.18)
Final							3.81 (2.32)	2.11 (1.53)	4.31 (2.30)

Note. Means and standard deviations (in parentheses) in the subcomponents of the SSE and EVEA other than those assessing sadness for the two induction groups and phases of the experiments. A series of 2 (group) × 3 (time) ANOVAs carried out on each of these measures revealed no effect of group, time, or interaction between these factors, except for an increase in anger and hostility and a decrease in happiness (SSE) in the sadness group after induction, an increase in anxiety (EVEA) in both groups following the cross-oddball task, and a decrease in happiness (EVEA) after induction in the sadness group.