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Happiness increases distraction by auditory deviant stimuli

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Rare and unexpected changes (deviants) in an otherwise repeated stream of task-irrelevant auditory distractors (standards) capture attention and impair behavioural performance in an ongoing visual task. Recent evidence indicates that this effect is increased by sadness in a task involving neutral stimuli. We tested the hypothesis that such effect may not be limited to negative emotions but reflect a general depletion of attentional resources by examining whether a positive emotion (happiness) would increase deviance distraction too. Prior to performing an auditory-visual oddball task, happiness or a neutral mood was induced in participants by means of the exposure to music and the recollection of an autobiographical event. Results from the oddball task showed significantly larger deviance distraction following the induction of happiness. Interestingly, the small amount of distraction typically observed on the standard trial following a deviant trial (post-deviance distraction) was not increased by happiness. We speculate that happiness might interfere with the disengagement of attention from the deviant sound back towards the target stimulus (through the depletion of cognitive resources and/or mind wandering) but help subsequent cognitive control to recover from distraction.

Efficient cognitive functioning depends in part on the ability to deal with irrelevant stimuli susceptible of interfering with the performance of a task at hand and the attainment of our immediate goals. Numerous studies have focused on identifying characteristics rendering irrelevant stimuli more prone to capturing our attention, such as their emotional valence. In this line of research, it has been widely demonstrated that negative or biologically relevant irrelevant stimuli can capture attention, divert attention from the ongoing task, and thereby impair cognitive performance (Campanella *et al.*, 2002; Delplanque, Silvert, Hot, & Sequeira, 2005; Domínguez-Borràs, Garcia-Garcia, & Escera, 2008; Domínguez-Borràs *et al.*, 2009; Lv, Wang, Tu, Zheng, & Qiu, 2011). For example, participants are typically slower to find a visual target when distractors consist of pictures of threatening stimuli (Blanchette, 2006). However, while there is strong evidence that emotional stimuli influence perception and the deployment of attention (see Dolan, 2002; Pessoa, 2008;

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Vuilleumier, 2005, for reviews), relatively less is known about how one's emotional state might affect attentional mechanisms in the face of neutral irrelevant stimuli.

Studies examining the impact of emotional states on cognitive functioning have mostly focused on negative emotions, typically because they relate to pathological conditions such as depression or anxiety disorders or in an attempt to design better clinical interventions (e.g., Gable & Haidt, 2005; Seligman, 2002). For example, studies exploring how mood influences spatial perception have shown that people in a sad mood estimate a hill to be steeper than those in a happy mood (Riener, Stefanucci, Proffitt, & Clore, 2011), or that the induction of a sad mood with movie clips prior to learning word lists reduces false memories in a recognition task (Storbeck & Clore, 2011). Such examples are interesting because they demonstrate the impact of sadness on tasks that do not involve emotional stimuli *per se*.

Interestingly, a few studies have found that the induction of a negative emotional state can affect fundamental attention mechanisms in conditions involving emotionally neutral stimuli. For example, Pacheco-Unguetti, Acosta, Callejas, and Lupiáñez (2010) found that inducing state anxiety through the presentation of complex pictures with negative valence resulted in an overfunctioning of the alerting and orienting attentional networks. Using a different methodology, Domínguez-Borràs *et al.* (2008, 2009) found that participants engaged in a picture comparison task were significantly more distracted by rare and unexpected changes in a sequence of neutral irrelevant sounds when these were preceded and followed by negative pictures or faces compared with neutral ones. Distraction by rare and unexpected deviations in a sequence of otherwise repeated or structured irrelevant sounds is referred to as deviance distraction and reflects the fact that these deviant sounds trigger an involuntary orienting of attention towards them that, in turn, requires the re-orientation of attention towards the task-relevant stimuli (e.g., Berti, 2008; Berti & Schröger, 2001; Schröger, 1996).

Behaviourally, deviance distraction is marked by longer response times to target stimuli (and in some studies lower accuracy) following a deviant sound than following the standard sound (e.g., Escera, Alho, Winkler, & Näätänen, 1998; Parmentier, 2008; Parmentier, Maybery, & Elsey, 2010; see Parmentier, 2014, for a review). This effect is thought to result from the capture of attention by stimuli violating the predictions of the cognitive system (Bendixen, SanMiguel, & Schröger, 2013; Bendixen & Schröger, 2008; Bendixen *et al.*, 2010; Parmentier, Elsley, Andrés, & Barceló, 2011; Schröger, Bendixen, Trujillo-Barreto, & Roeber, 2007) and reflect the cost of orienting attention to and away from the deviant sound (Parmentier, Elford, Escera, Andrés, & San Miguel, 2008). While triggered by a violation of sensory predictions, it is subject to top-down mediation by factors such as working memory load (e.g., SanMiguel, Corral, & Escera, 2008), individual differences in working memory (e.g., Sörqvist, Nöstl, & Halin, 2012), cognitive control (e.g., Parmentier & Hebrero, 2013), the informative value of the irrelevant sounds for goal-directed behaviour (e.g., Parmentier, Elsley, & Ljungberg, 2010), the semantic content of the deviant sound (e.g., Parmentier, Turner, & Perez, 2014), ageing (e.g., Andrés, Parmentier, & Escera, 2006), the emotional valence of the visual context (e.g., Domínguez-Borràs *et al.*, 2008), the arousing value of the deviant sounds (Max, Widmann, Kotz, Schröger, & Wetzel, 2015), or the participant's emotional state (Pacheco-Unguetti & Parmentier, 2014). Finally, a small but significant amount of distraction has been observed on the first standard trial following a deviant trial (e.g., Ahveninen *et al.*, 2000; Berti, 2008), an effect referred to as post-deviance distraction. According to Roeber, Widmann, and Schröger (2003), post-deviance distraction 'may reflect an ongoing process of re-allocation of attention back to the task-relevant stimulus property after the occurrence of an attention-catching task-irrelevant deviation' (Roeber *et al.*, 2003, p. 355; see also Berti, 2008; Roeber, Berti, Widmann, & Schröger, 2005). Such effect certainly suggests that deviants elicit some cognitive interference beyond the resolution of the trial in progress, reminiscent of what is observed in task switching studies (e.g., Meiran, Chorev, & Sapir, 2000; Rogers & Monsell, 1995). Parmentier and Andrés (2010) suggested that deviance distraction might primarily involve the disengagement from distractors and the reactivation of the relevant task set upon the presentation of the target stimulus, while post-deviance distraction might reflect processes required for the completion of the task-set reactivation.

Pacheco-Unguetti and Parmentier (2014) recently reported that participants focusing on a visual task were significantly more sensitive to distraction by deviant sounds when in an induced state of sadness. Participants in that study received a sadness or neutral induction by way of listening to sad or neutral music (see Vuoskoski & Eerola, 2012, for evidence of the emotional impact of sad music) and recalling the saddest event of their life (sadness condition) or their latest trip to the grocery store (neutral condition). Following induction, participants undertook a cross-modal oddball task in which they categorized the parity of visual digits while ignoring the irrelevant sound (standard or deviant) presented before each digit. Relative to the neutral condition, sadness increased deviance distraction by a factor of two (while post-deviance distraction increased numerically but not significantly). The authors suggested two possible explanations for this effect. The first was that sadness increased deviance distraction by relaxing attentional filters to irrelevant information, a reaction related to sadness' adaptive function, namely to signal that the current situation is problematic and promote a more vigilant and systematic appraisal of the external environment (Bodenhausen, Gabriel, & Lineberger, 2000; Forgas, 2007; Gasper, 2004; Schwarz & Clore, 1996). Such account fits, for example, with the suggestion of a lower activation threshold for the P3a (typically regarded as an index of the involuntary orienting of attention towards deviant stimuli; Escera *et al.*, 1998; Schröger & Wolff, 1998) response to novel sounds when participants are exposed to a negative video clip (Gulotta, Sadia, & Sussman, 2013). The second proposed account was that sadness increased the difficulty in disengaging attention from the deviant sound and re-orienting it towards the target stimulus because sadness monopolized attentional resources (possibly by or in conjunction with triggering ruminating thoughts). Such account fits with some theoretical views proposing that mood can increase cognitive interference because it consumes resources (e.g., Ellis & Ashbrook, 1988), and is in line with the proposition that mood can act as a cognitive load (Ellis, Moore, Varner, & Ottaway, 1997; Meinhardt & Pekrun, 2003; Mitchell & Phillips, 2007; Phillips, Smith, & Gilhooly, 2002; Seibert & Ellis, 1991). This latter idea is interesting because it does not limit the impact of emotions to sadness or other negative ones. Instead, it predicts that any enhanced resource-consuming emotional state, negative or positive, may affect attention. This naturally leads to a simple question: Would deviance distraction also increase when participants are in a positive emotional state such as happiness?

We hypothesized that if deviance distraction is sensitive to enhanced emotional states regardless of their valence (positive or negative), then inducing happiness should yield results similar to those found for sadness (Pacheco-Unguetti & Parmentier, 2014). More specifically, we predicted that happiness should yield a significant increase in deviance distraction. With respect to post-deviance distraction, there were two possible outcomes: If happiness and sadness affect attention in the same manner, post-deviance should not vary with the induction (in line with Pacheco-Unguetti & Parmentier, 2014). On the other hand, if happiness increases distractibility but enhances cognitive flexibility and cognitive control as positive emotions have been found to do in other paradigms (Dreisbach & Goschke, 2004; Van der Stigchel, Imants, & Richard Ridderinkhof, 2011), post-deviance distraction (because it has been associated with cognitive control; e.g., Berti, 2008) may be reduced by happiness. To explore these issues, we carried out an experiment in which we induced happiness or neutral mood states before participants took part in a cross-modal oddball task.

Method

Participants

Forty-four undergraduate students (36 females) took part in this study in exchange for a small honorarium. Participants were between 17 and 28 years old ($M = 20.15$, $SD = 2.20$) and all of them reported normal hearing and normal or corrected-to-normal vision.

Mood induction procedure

To induce positive and neutral mood states, we used an experimental mood induction procedure (MIP) combining background music and autobiographical memory retrieval (see Martin, 1990 for a review of the effectiveness of these methods). In the positive-MIP condition, participants were asked to recall, as vividly as possible, the happiest event in their life. They were encouraged to carefully remember and evoke details of that situation, how they felt, what their thoughts were at the time, and to immerse themselves as deeply as possible in the mood they felt at that moment. Participants were given 4 min to remember this happy event, after which they were instructed to write down on a sheet of paper as detailed a description of the event as possible during 5 min. In the neutral-MIP condition, the procedure was identical with the difference that participants were asked to remember a recent trip to the grocery store. They were encouraged to recollect details of the shop and their actions in it (location, departments, purchased items, etc.). Throughout the MIP, participants were exposed to background musical pieces through headphones. In the positive-MIP condition, three musical pieces were played: 'Mazurka from Coppelia' by Delibes, 'Eine Kleine Nachtmusik' by Mozart, and 'Allegro from Brandenburg Concerto No. 2' by Bach. These pieces were selected from prior work for their ability to induce a positive mood (Huntsinger, Clore, & Bar-Anan, 2010; Jallais & Gilet, 2010; Mayer, Allen, & Beauregard, 1995; Riener *et al.*, 2011; Schmid & Schmid Mast, 2010; Storbeck & Clore, 2005; Talbot, Hairston, Eidelman, Gruber, & Harvey, 2009). In the neutral-MIP condition, the musical pieces used were 'The Planets, Op. 32: VII. Neptune, the Mystic' by Gustav Holst and the Largo movement from 'New World Symphony' by Antonín Dvořák, both selected for their emotional neutrality (Au Yeung, Dalgleish, Golden, & Schartau, 2006; Berna *et al.*, 2010; Robinson, Cools, Crockett, & Sahakian, 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;Sandín *et al.*, 1999; Watson, Clark, & Tellegen, 1988) before and after induction. 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 Self-Assessment Mannequin test (SAM; Lang, 1980) 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 emotional scales: Pleasure (from 1, 'pleasant', to 5, 'unpleasant'), arousal (from 1, 'excited', to 5, 'calm'), and dominance (from 1, 'controlled', to 5, 'dominant').

Auditory-visual 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 sound files were normalized to peak amplitude levels (peak normalization increases the sound's amplitude to its highest level before there is clipping or distortion and preserves the sounds' dynamics), and edited to include 10 ms rise and fall ramps. Sounds were delivered binaurally through headphones at a level of approximately 70 dB (SPL).

Each trial involved the presentation of a sound followed by a visual digit (in white colour against a black screen) with a sound-to-digits stimulus onset asynchrony of 250 ms. Digits appeared for 200 ms at the centre of the screen and subtended an angle of approximately 2.6°, temporarily replacing the fixation cross that was otherwise always visible at the centre of the screen. Upon the digit's offset, the fixation cross re-appeared for 700 ms during which time participants were required to press a key to categorize each digit as odd or even as quickly as possible while trying to make no mistake.

Participants completed two blocks of 180 test trials each. Each block was preceded by 12 practice standard trials that were not included in the data analysis. In each block, the digits 1–6 were used equally often in each of the two sound conditions (standard and 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 keys to responses was counterbalanced across participants) and they were told that the sounds were distracters that had to be ignored.

Procedure

Participants were tested individually in a dimly lit cubicle, in one session that lasted approximately 30 min. Upon arrival at the laboratory, participants were provided with 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, and signed a consent form. After that, they completed the PANAS for the first time with the explicit instruction to indicate how they felt at that moment (immediately before the mood induction). Participants were encouraged to respond sincerely and truthfully to the questionnaire. Once completed, participants were randomly assigned to one of the two groups (positive or neutral mood induction) and were instructed to put the headphones on and follow instructions appearing on the computer screen in order to begin the mood induction phase while listening to music. The music played throughout the induction and completion of the post-induction questionnaire (the PANAS) and turned off before participants proceeded to partake in the oddball task. After completing the oddball task, participants filled out the SAM to evaluate the musical pieces presented throughout the MIP, before being debriefed.

Results

Mood manipulation check

In the recall-writing task of the positive mood induction group, eight participants recalled events related to academic circles (school graduation, achieving the required grade to study a desired degree), four participants reported the birth of a younger sibling or nephew, three participants recalled a family trip, two participants recalled a birthday party, two participants reported a significant moment with their partner, two reported the moment of meeting a loved one again after years, and one participant recalled a live concert experience. In the neutral mood induction group, none of the participants reported details of any incident or event that could be considered especially positive or negative; rather, they were all neutral.

PANAS-PA scores taken before and after the MIP were entered into a 2 (group: Positive vs. neutral mood induction) × 2 (time: Before vs. after induction) ANOVA. The main effects of group, $F(1, 42) = 5.39$, $MSE = 68.98$, $p = .025$, $\eta_p^2 = .11$, and time, $F(1, 42) = 12.83$, $MSE = 20.72$, $p < .001$, $\eta_p^2 = .23$, were significant. The interaction between these variables did not reach statistical significance, $F(1, 42) = 2.61$, $MSE = 20.72$, $p = .113$, $\eta_p^2 = .05$, although numerically the data go in the direction of an increase in positive score with the positive induction (see Table 1). The same analysis performed on the PANAS-NA scores revealed a significant main effect of time, $F(1, 42) = 8.71$, $MSE = 13.03$, $p = .005$, $\eta_p^2 = .17$. The main effect of group was not significant, $F(1, 42) = 2.52$, $MSE = 27.5$, $p = .119$, $\eta_p^2 = .05$, and neither was the group × time interaction, $F(1, 42) = 0.22$, $MSE = 13.03$, $p = .639$, $\eta_p^2 = .005$.

Mood-supportive musical pieces assessment

An ANOVA performed on SAM valence ratings revealed significant differences between the groups in valence ratings. The songs presented to the positive induction group were rated as significantly more pleasant than those presented to the neutral group, $F(1, 42) = 8.65$, $MSE = 0.75$, $p = .005$, $\eta_p^2 = .17$ ($M = 1.50$, $SD = .59$, vs. $M = 2.27$, $SD = 1.07$, respectively). The positive and neutral songs did not differ with respect to arousal ratings, $F(1, 42) = 1.63$, $MSE = 1.12$, $p = .208$, $\eta_p^2 = .03$ ($M = 2.90$, $SD = 0.92$,

Table 1. Means and standard deviations (in parentheses) in the Positive Affect (PA) and Negative Affect (NA) subscales of the PANAS questionnaire for the different mood induction groups

	PANAS-PA	PANAS-NA
Positive mood induction		
Pre-MIP	33.00 (8.60)	14.90 (4.88)
Post-MIP	38.04 (5.70)	12.27 (3.32)
Neutral mood induction		
Pre-MIP	30.45 (5.40)	16.31 (4.86)
Post-MIP	32.36 (6.60)	14.40 (4.70)

Note. MIP = mood induction procedure; PANAS = Positive and Negative Affect Schedule.

vs. $M = 2.50$, $SD = 1.18$, respectively), or in terms of dominance, $F(1, 42) = 1.13$, $MSE = 0.98, p = .293, \eta_p^2 = .02$ ($M = 3.27$, $SD = 1.07$, vs. $M = 2.95$, $SD = 0.89$, respectively).

Oddball task performance: Proportion correct responses

A 2 (group: Positive vs. neutral mood induction, between participants) × 3 (trial type: Standard, post-deviant standard, deviant, within-participant) ANOVA for mixed designs was carried out on the mean proportion of correct responses. The main effect of group was not significant, $F(1, 42) = 0.559, MSE = 0.041, p = .459, \eta_p^2 = .013$, and neither was the group × trial type interaction, $F(2, 84) = 0.252, MSE = 0.003, p = .777, \eta_p^2 = .006$. The effect of trial type was significant, $F(2, 84) = 9.359$, $MSE = 0.003$, $p < .001$, $\eta_p^2 = .182$, showing that participants responded significantly more accurately in the standard condition than in the deviant condition (deviance distraction), $F(1, 42) = 11.184$, $MSE = 0.004$, $p < .005$, $\eta_p^2 = .211$. However, no difference in accuracy was found between the standard and post-deviant standard conditions (no post-deviance distraction), $F(1, 42) = 1.171$, $MSE = 0.001$, $p = .285$, $\eta_p^2 = .027$ (see Figure 1).

Oddball task performance: Response latencies for correct responses

The same analyses as above were conducted for the mean response latencies for correct responses. The main effect of group was not significant, $F(1, 42) = 0.650, MSE = 7{,}259$, $p = .650, \eta_p^2 = .005$, but that of trial type was, $F(2, 84) = 34.997, MSE = 443, p < .001$, $\eta_p^2 = .454$. Importantly, the group × trial type interaction was significant as well, $F(2, 84) = 5.712, MSE = 443, p < .005, \eta_p^2 = .120$. Further contrasts were carried out to

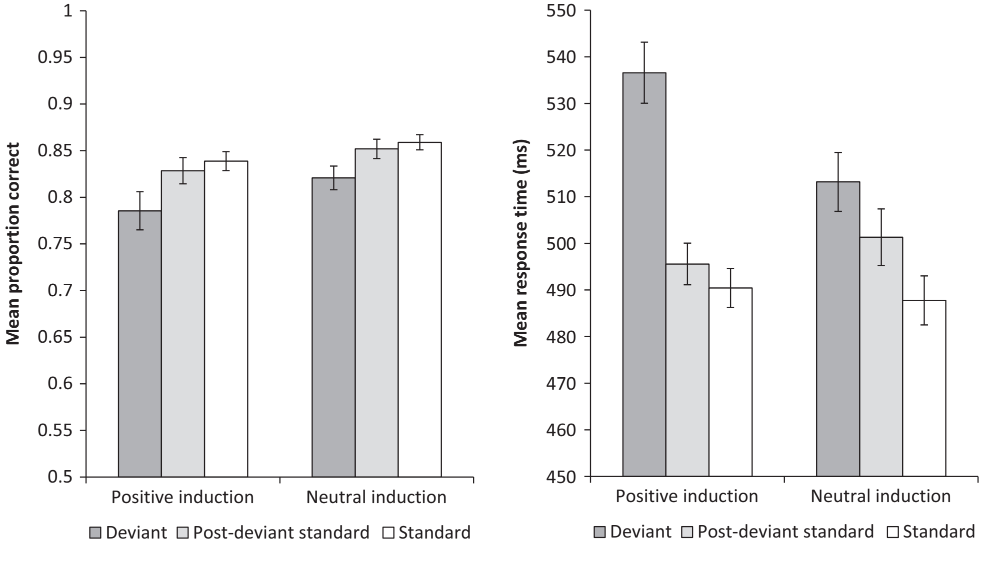

Figure 1. Mean response accuracy (Left Panel) and mean response times (Right Panel) in the cross-modal oddball task as a function of the induction condition (negative, neutral) and the trial type (deviant, post-deviant standard, standard). Error bars represent one standard error of the mean.

explore this interaction. Deviance distraction (RT deviant − RT standard) was significant in both groups, neutral: $F(1, 42) = 13.898$, $MSE = 510.880$, $p < .001$, $\eta_p^2 = .551$, positive: $F(1, 42) = 45.801$, $MSE = 510.880$, $p < .001$, $\eta_p^2 = .560$, but greater in the positive than in the neutral, $F(1, 42) = 4.620$, $MSE = 510.88$, $p < .05$, $\eta_p^2 = .010$. In contrast, post-deviance distraction (RT post-deviant standard − RT standard) was significant in the neutral group, $F(1, 42) = 11.839$, $MSE = 170.016$, $p < .005$, $\eta_p^2 = .376$, but not in the positive group, $F(1, 42) = 1.693$, $MSE = 170.016$, $p = .200$, $\eta_p^2 = .071$.

In order to confirm the dissociation between deviance distraction and post-deviance distraction, we carried out a 2 (group: Positive vs. neutral mood induction, between participants) × 2 (distraction type: Deviance vs. post-deviance distraction) ANOVA for mixed designs. The main effect of group was not significant, $F(1, 42) = 1.118$, $MSE = 744.540$, $p = .296$, $\eta_p^2 = .026$. Not surprisingly, deviance distraction was significantly greater than post-deviance distraction, $F(1, 42) = 24.920$, $MSE = 317.250$, $p < .001$, $\eta_p^2 = .373$. Most importantly, the group × distraction type interaction was significant, $F(1, 42) = 7.559$, $MSE = 617.250$, $p < .01$, $\eta_p^2 = .153$, revealing that, relative to the neutral condition, the positive induction increased deviance distraction, $F(1, 42) = 4.620$, $MSE = 1021.758$, $p = .037$, but not post-deviance distraction, $F(1, 42) = 2.289$, $MSE = 340.032$, $p = .138$. In fact, numerically, the positive induction reduced post-deviance distraction (as visible from Figure 1).

Happiness versus sadness: Comparison with Pacheco-Unguetti and Parmentier (2014)

In this section, we compare the effect of the happiness induction in the present study with the sadness induction we reported in an earlier study (Pacheco-Unguetti & Parmentier, 2014). This comparison is made especially suitable because the mood induction method (exposure to music, autobiographical recollection), and the oddball task were identical in all respects in the two studies, and because the sample sizes were similar in the two experiments (40 vs. 44 in the present study). A 2 (mood: Happiness vs. sadness) × 2 (deviance distraction: Standard vs. Deviant) ANOVA on RTs for correct responses revealed no main effect of mood condition, $F(1, 40) < 1$, $MSE = 5{,}703$, $p = .324$, $\eta_p^2 = .024$, but a main effect of distraction with longer RTs in the deviant condition than in the standard, $F(1, 40) = 65.801$, $MSE = 665$, $p < .001$, $\eta_p^2 = .622$. Importantly, deviance distraction was equivalent for both mood inductions, $F(1, 40) < 1$, $MSE = 665$, $p = .940$, $\eta_p^2 = .0001$. A 2 (mood: Happiness vs. sadness) × 2 (post-deviance distraction: Standard vs. Post-deviant standard) ANOVA on RTs for correct responses revealed no main effect of mood condition, $F(1, 40) = 2.174$, $MSE = 5{,}190$, $p = .148$, $\eta_p^2 = .052$, as well as a main effect of distraction with longer RTs in the deviant condition than in the standard, $F(1, 40) = 14.834$, $MSE = 184$, $p < .001$, $\eta_p^2 = .271$. Importantly, post-deviance distraction was significantly smaller for the happiness than for the sadness induction, $F(1, 40) = 4.509$, $MSE = 184$, $p = .040$, $\eta_p^2 = .101$. Hence, direct statistical comparisons between the studies confirmed our qualitative observations: Induced happiness yielded deviance distraction similar to induced sadness but significantly less post-deviance distraction.[1]

[1] *As per request of one anonymous reviewer, we also compared the neutral groups in the present study and that of Pacheco-Unguetti and Parmentier (2014) and confirmed that they were comparable: They exhibited equivalent levels of deviance and post-deviance distraction (Fs < 1) and similar PANAS-AP and PANAS-AN scores (Fs < 1).*

Discussion

We reported an experiment examining the impact of positive mood on behavioural deviance distraction following the induction of happiness or a neutral mood. The results showed that participants exhibited significantly longer response times (and fewer correct responses) in the visual categorization task following the presentation of deviant sounds relative to standard sounds. More importantly, happiness produced a large increase in deviance distraction compared with neutral mood. Yet, despite this marked increase, happiness exhibited a relative reduction in post-deviance distraction. We comment on these two findings in turn below.

Starting with deviance distraction, it is worth highlighting that the increase in deviance distraction was observed in a task involving emotionally neutral stimuli while past work interested in the interplay between emotions or emotional contexts and attention capture traditionally employed emotionally laden stimuli (Campanella *et al.*, 2002; Delplanque *et al.*, 2005; Domínguez-Borràs *et al.*, 2008, 2009; Gulotta *et al.*, 2013; Lv *et al.*, 2011). The latter can be problematic because it makes it difficult to ascertain whether effects are mediated by the emotions such stimuli trigger or, instead, reflect differential processing for these stimuli compared with neutral ones. In our study, we used the exact same neutral stimuli in both groups, thereby ruling out stimuli-specific effects. In sum, our data suggest that one's emotional state, in this case positive, affects attention for neutral stimuli.

The fact that deviance distraction increased with a positive induction warrants further commenting. In particular, it suggests that the increase in distraction is not limited to the effect of sadness (Pacheco-Unguetti & Parmentier, 2014) but applies to a positive emotional state such as happiness as well. Two potential explanations may be offered to account for this similarity. First, our results are compatible with theories proposing that emotions (regardless of their polarity) consume cognitive resources (e.g., Ellis & Ashbrook, 1988). If so, happiness, just as sadness, may deplete resources otherwise necessary to disengage from the deviant stimuli. Such depletion may be central (emotions using up mental energy that cannot therefore be devoted to the control of attention) or possibly due to mood-evoked intrusive thoughts acting as a cognitive load (e.g., Ellis *et al.*, 1997; Meinhardt & Pekrun, 2003; Phillips, Smith, *et al.*, 2002). However, the hypothesis of happiness as a cognitive load does not fit well with the finding that a mental load does not increase but, instead, reduces behavioural distraction to deviant sounds (Berti & Schröger, 2003; SanMiguel *et al.*, 2008). Second, it may be that emotional states affect the permeability of attention filters, bias attention towards novel stimuli, or reduce the ability to inhibit irrelevant information. For example, according to Fredrickson's broaden-and-build theory (1998, 2001), positive emotions broaden the scope of cognition, attention, and action, and lead one to perceive the environment as safer and more stable, resulting in the more even distribution of attention across the immediate environment, in broadening thinking and enhancing perception, and in being more open to exploring novel objects or performing actions. This idea has been supported by studies reporting that positive emotions yield an improvement in performance in tasks requiring creativity (Hirt, Devers, & McCrea, 2008), verbal fluency (Phillips, Bull, Adams, & Fraser, 2002), unusual word associations creative problem-solving, decision-making, and various others (see Isen, 2008; for a review). Based on this model, positive emotional states expand the scope of attention and encourage cognitive and behavioural flexibility (Isen, Niedenthal, & Cantor, 1992), although with a cost in the form of an increased impulsivity and sensitivity to irrelevant information (Dreisbach & Goschke, 2004). In the same way, some evidence suggests that negative emotional states lead people to be more sensitive to external information, as they indicate that the current environment is problematic and therefore motivate the processing of information in a more vigilant and detailed-oriented manner, possibly in order to attain some predictability and control over the situation (e.g., Bodenhausen *et al.*, 2000; Forgas, 1995; Gasper, 2004; Schwarz & Clore, 1996).

Also, both mood states are related to intentional or unintentional cognitive distraction. In the case of sadness, distracting or drawing attention away from sad thoughts or ruminations is an effective coping strategy that helps us restore a more neutral mood state (i.e., Gross, 1998; Lazarus, 1991). As for positive moods, they appear to be linked with a global relaxation of inhibitory control that is reflected in a reduced attention selection, thereby increasing the propensity of distractors to enter the focus of attention. For example, positive affect has been shown to hinder selective attention in flanker tasks (Rowe, Hirsh, & Anderson, 2007), decrease task performance when novel stimuli are presented as distracters in set switching tasks (Dreisbach & Goschke, 2004), or enhance the implicit learning of distracting information when it can subsequently help performance (Biss, Hasher, & Thomas, 2010; Schmitz, De Rosa, & Anderson, 2009).

With regard to post-deviance distraction, our results are interesting because they provide the first demonstration of a concurrent increase in deviance distraction in the absence of an increase in post-deviance distraction. In fact, numerically, post-deviance distraction decreased in the positive induction condition. In comparison with the effect of sadness reported by Pacheco-Unguetti and Parmentier (2014), the positive induction reduced post-deviance distraction. This suggests that post-deviance distraction is not a mere residue of deviance distraction surviving deviant trials but may, instead, involve functionally distinct cognitive mechanisms. Some authors argued that a specificity of the first standard trial following a deviant trial is its requirement to complete a task-set reconfiguration initiated on the deviant trial or, put simply, to re-stabilize the cognitive set following a perturbation (Berti, 2008; Parmentier & Andrés, 2010). If so, our results suggest that induced happiness may boost this mental reconfiguration process. While this had not previously been demonstrated in the context of a cross-modal oddball task, such suggestion fits with the proposition from a task switching study by Dreisbach and Goschke (2004) that positive affect (induced through the exposure to pictures) increases distractibility but also (and in contrast to neutral or negative affect) promotes cognitive control (see also Van der Stigchel *et al.*, 2011, for converging evidence using a antisaccade task).

In summary, our results show that the induction of a positive mood (happiness) increases deviance distraction, thereby demonstrating that negative emotions are not unique in yielding this effect. Importantly, this was observed with neutral stimuli, thereby indicating that the enhancement of distraction by one's emotional state is not limited to emotionally loaded stimuli but affects fundamental aspects of attention.

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