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The Influence of Alexithymia and Music on the Incidental Memory for Emotion Words

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Abstract
Alexithymia is a multifaceted personality construct which encompasses difficulties in identifying and expressing feelings along with an externally oriented cognitive style. We investigated whether congruent vs. incongruent emotional musical priming (happy and angry music) during encoding would moderate the effects of alexithymia on recognition rates. We found that high alexithymia scorers recognized fewer joy and anger words than low scorers. Angry music decreased recognition rates in high alexithymia scorers compared to low alexithymia scorers. The congruency and incongruency effects between music and words depended on alexithymia level. The anger deficit in high alexithymia scorers and the possible support provided by happiness cues are discussed. Copyright © 2010 John Wiley & Sons, Ltd.

Key words: alexithymia; anger; arousal; memory; recognition; music; happy cue; personality

INTRODUCTION

Alexithymia is a multifaceted construct that includes difficulties identifying feelings and distinguishing between feelings and the bodily sensations of emotional arousal, difficulties describing feelings to others, and a cognitive style that is literal, utilitarian and externally oriented (Taylor, 1994). To illustrate, when confronted with stressful situations, externally oriented people will only have images and representations that duplicate action, without fantasies and feelings that usually accompany them. Alexithymia is also related to a reduced capacity to engage in fantasy and other imaginal activities. These cognitive and affective characteristics were initially observed among patients with classic psychosomatic diseases (Nemiah, Freyberger, & Sifneos, 1976), but were later observed in psychiatric patients including for instance substance use disorders, post-traumatic stress disorders and

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eating disorders (see for review Taylor, Bagby, & Parker, 1997). It has been suggested that the features comprising the Alexithymia construct reflect a global deficit in the cognitive processing and regulation of emotions (Taylor et al., 1997). Importantly, Alexithymia was found to be related to significant negative outcomes on health-related dimensions, such as decreased life expectancy (Kauhanen, Kaplan, Cohen, Julkunen, & Salonen, 1996).

A growing body of empirical support is now emerging about the deficits involved in the processing of emotional information in high alexithymia scorers. For instance, high alexithymia scorers report lower intensity of emotional responses at the cognitive/experiential level to an emotional visual stimulus (i.e. together with increased physiological responses; (Luminet, Rime, Bagby, & Taylor, 2004)). In addition, an event-related potential (ERP) study showed that high alexithymia scorers correctly perceived and categorized aversive pictures but that they needed more cognitive resources to do so (Franz, Schaefer, Schneider, Sitte, & Bachor, 2004). This study on brain functioning suggests that high alexithymia scorers' brains process emotional stimulation less efficiently.

Recent findings on emotional information processing in alexithymia also emphasize a specific deficit in anger processing. First, one brain area (i.e. the Anterior Cingulate Cortex) was found to be more activated in high alexithymia scorers judging the gender of angry faces (Meriau et al., 2006). Second, by using the affective priming paradigm, a reduced affective priming effect was found in high alexithymia scorers when presented with an angry facial prime followed by a positively or a negatively valenced to-be-evaluated target word (Vermeulen, Luminet, & Corneille, 2006). Finally, an ERP study found a delayed attentional orientation towards emotional facial expression of anger in high alexithymia scorers (Vermeulen, Luminet, Cordovil de Sousa, & Campanella, 2008). These studies point to a disturbance in anger processing in high alexithymia scorers. As suggested earlier, the fact that alexithymia is particularly related to difficulties with anger processing would be deleterious for adaptation because threatening stimuli are highly arousing and require quick self-regulating responses in order to cope with future behavioural demands (Vermeulen et al., 2008). In that sense, all the above-mentioned findings are also in line with the reducing/augmenting hypothesis of alexithymia (Morrison & Pihl, 1990). This hypothesis suggests that because high alexithymia scorers are less able to use emotional content to distinguish relevant from irrelevant information, alexithymia could lead people to use adaptive mechanisms such that enhancing environmental stimuli processing in order to prevent omitting potentially dangerous stimuli. This hypothesis was recently supported by an ERP research that showed that high alexithymia scorers had augmented ERP amplitudes when stimulated with sounds of high intensity level (i.e. 95 dB; Schafer, Schneider, Tress, & Franz, 2007). In other words, this theory claims that because high alexithymia scorers have difficulties to discriminate emotional informations, they would in turn augment stimuli in order to prevent ignoring potentially harmful stimuli. Such a theory might explain why studies have found reduced automatic processing of emotional features (e.g. Vermeulen et al., 2006, 2008) while others found that alexithymics engaged more resources either to categorize emotions (Franz et al., 2004) or to disengage from irrelevant emotional content (Meriau et al., 2006). Although high alexithymia scorers do not automaticlly detect and use emotional features, the augmenting response pattern would allow them to allocate additional resources to emotional stimuli. However, this pattern will later make them less able to regulate and to disengage from those emotional features. From that perspective, high alexithymia scorers could be at risk of developing diseases related to increased arousal level due to lower regulation abilities for negative affect (see for instance Luminet et al., 2004).

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Memory functioning represents an interesting part of the empirical validation of the construct. Among the few studies published on this issue, most have found a deficit in recognition memory for emotional stimuli in alexithymia (Luminet, Vermeulen, Demaret, Bagby, & Taylor, 2006; Suslow, Kersting, & Arolt, 2003; Vermeulen & Luminet, 2009). However, one study did not find any difference in episodic memory between low and high alexithymia scorers (Lundh, Johnsson, Sundqvist, & Olsson, 2002). Therefore, more research is needed to clarify these contradictory findings.

A number of questions remain unanswered, however, regarding memory performance for high alexithymia scorers. For instance, an important but yet unstudied question is whether high alexithymia scorers could be influenced by an emotional (in)congruent[1] context during encoding of emotional information (Luminet et al., 2006). This assumed moderating impact of alexithymia on an emotional context relied on previous data showing a moderating impact of alexithymia on cognitive control necessary to allocate attentional resources (Meriau et al., 2006). Meriau and colleagues found that alexithymia was related to increased activation in brain regions involved in general monitoring functions during the processing of fearful and angry faces. Indeed, they found that alexithymia covaried positively with anterior cingulated cortex activity during gender decisions (i.e. Male vs. Female) but not during emotion decisions. For the authors, these data showed that high alexithymia scorers engaged in greater cognitive control to allocate attentional resources to gender-relevant features, and to disengage attention from anger- and fear-related emotional content (irrelevant to the gender task). To examine this question of the emotional (in)congruency context, we decided to use a musical priming procedure. This procedure is very different from the classic mood induction procedure using music that overtly orients participants attention towards their felt emotions. On the contrary, musical priming ensures that participants automatically and implicitly processed the emotional content of the music and this procedure allows researchers to measure congruency–incongruency effects between diplayed music and words without modifying the participant's mood. The musical priming procedure we used was based on findings showing that word evaluation can be influenced by the mere presentation of musical elements that are processed as emotional primes (Sollberger, Reber, & Eckstein, 2003). The emotional responses to music are partly related to an emotional contagion effect in the listener (for discussion see Juslin & Västfjäll, 2008). The main interest is therefore that such priming effects are unintended and implicitly triggered. We suggest that musical *congruency effects at encoding* could help high alexithymia scorers to efficiently process and store emotion concepts with the musical prime working as a cue for recognizing the stimuli during the recognition step, which ought to reduce the emotional deficits in alexithymia.

In the present experiment, we rely on a discrete emotions approach with anger and joy emotions. The aim of the present study is to investigate whether the retention of happy and angry words is influenced by alexithymia level and by the presentation of happy or angry musical primes during word encoding. We decided to manipulate the encoding stage so that participants had to either process words at a shallow (i.e. perceptual) or at a deep (i.e. semantic) level of processing. We expected to find the interaction between words and music more present during semantic processing than during perceptual processing of

[1]Congruency/incongruency effects are not due to transformations of the variables (like computation of new indices involving neutral primes). In the affective priming literature for instance, researchers usually speak about congruency/incongruency effects depending on the prime-target pairs relation (but independently of a baseline condition using neutral primes). These terms only refer to a description of the relation between music and words (i.e., whether they share the same discrete emotional content or not).

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words. Indeed, because the meaning of words is only superficially accessed during perceptual processing, the displayed emotional music could only moderately interfere with emotionality of the words. We decided to use the level of processing paradigm as a between-subject manipulation in order to prevent our participants from processing the emotional meaning of the words (i.e.as expected in the semantic level of processing) during the graphemic/perceptual level of processing. Therefore, during the graphemic processing, our participants did not voluntarilly orient their processing style towards emotional evaluation. Because we did not want our participants to be involved in negative emotional stimulations only, we chose to contrast our anger condition with a happiness condition for both music and words.

We first hypothesized, based on previous findings (e.g. Luminet et al., 2006), that alexithymia would decrease the overall recognition of emotional words (joy and anger). Second, based on previous findings showing a deficit in anger processing, we expected a moderating impact of alexithymia on memory performance in the angry music condition with an overall reduction of memory rates in high alexithymia scorers. Indeed, we suggest that once high scorers would be aroused by angry music, they would be less able to later control and disengage from this arousing influence which would generally disturb them during the main task (unintentional encoding of words). In the same way, we expected a larger deficit for anger words than for joy words.

Finally, in a third hypothesis, we expected that the interaction between words (Joy vs. Anger) and musical prime (Happy vs. Angry) would be moderated by alexithymia level, with greater (in)congruency effects observed in high alexithymia scorers. As mentioned earlier, high alexithymia scorers need more cognitive resources to perceive and categorize emotions (Franz et al., 2004). As a result, during the first 300 milliseconds of the emotional processing they are delayed in their ability to make affective judgments and to categorize emotions (Vermeulen et al., 2006, 2008). Once the perceptual and attentional processing of emotional content is completed, even if high scorers are physiologically aroused when processing emotionally salient events, they nevertheless show some difficulties to consciously access (i.e. less experience), control and disengage attention from such activation. For instance, it has been demonstrated that high scorers assess emotional events as less intense but evidence increased cardiovascular (HR) responses (Luminet et al., 2004). They also evidence a memory deficit that is particularly marked for conscious recollection of emotional words (i.e. memory responses, Luminet et al., 2006). Meriau *et al.* (2006) also found that alexithymia scores were positively correlated with increased activation in brain areas involved in attentional monitoring during gender processing of emotional (i.e. irrelevant features) faces. These last results clearly point to the difficulties for high scorers to control and to disengage from the emotional content of irrelevant information.

Based on those recent studies, we hypothesized that, once attentional resources have been devoted to the emotional content of music, high alexithymia scorers would encounter difficulties in disengaging their attention from the irrelevant musical content (see above, Meriau et al., 2006). The emotional properties of music will then influence the way they will process words. In an opposite manner, low alexithymia scorers would be better able to down-regulate the contextual emotion related to the musical content. This inability to distance oneself from the evoked musical emotional context would result, in high alexithymia scorers, in typical congruency/incongruency effects between memory rates for anger and happy words and musical primes (context). The reverse pattern should hold for low alexithymia scorers. Because they can easily inhibit the processing of musical emotion

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(better cognitive control of irrelevant emotional information; see Meriau et al., 2006), they ought to show incongruency when the emotional content of words and music matches. This should be the case because they ought to simultaneously inhibit the discrete emotional context related to the music (irrelevant to the encoding task) and the emotional content of the words belonging to the same category (e.g. joy words during happy music). In other words, low alexithymia scorers should be better able to control the emotional context while the reversed dysfunctional inability of high alexithymia scorers to inhibit irrelevant emotional context would become paradoxically beneficial in the case of congruency between positive music (irrelevant) and positive words (relevant).

METHOD

Participants and design

One hundred and seven students (75 women (70%), mean age = 21.1 years, SE = 0.23) from the Université catholique de Louvain (Belgium) participated in fulfilment of a course requirement. The present experiment conformed to a 2 (Level of processing: Perceptual vs. Semantic) $\times$ 2 (Music: Happy vs. Angry) $\times$ 4 (Type of emotion words: Neutral vs. Joy vs. Disgust vs. Anger) design, with level of processing and music as between subject factors and valence of words as a within subject factor. For the purpose of analysing the Alexithymia influence on congruency and incongruency effects, participants were classified as high vs. low in alexithymia based on a median-split of the questionnaire measure. In addition, neutral and disgust words were used either to complete the design (i.e. for the semantic condition) or to hide the purpose of the present experiment (i.e. by using disgust) and were therefore not entered in the ANOVA model. This was done because we were particularly interested in the interaction between music (happy vs. angry) and word type (joy vs. anger) (i.e. (in)congruency effects).

Material

Twenty-four emotion-related words were selected, with eight words related to each of the three emotion concepts ‘joy’ (e.g. smile, baby, happy), ‘disgust’ (e.g. excrement, vomit, nauseous) and ‘anger’ (e.g. fight, enraged, furious). Twenty-four words were unrelated to any emotion concept (e.g. substantive, quantified, chair, cube). All were pilot tested for their relation to specific emotions and how easy it was to imagine their referent (Niedenthal, 2007; Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009). These 48 target words were part of the 120 words pre-tested by Niedenthal *et al.* (2009) on a discrete emotion (joy, anger and disgust) scale from 1 ‘not related at all’ to 5 ‘highly related to’. Based on this pre-test, we examined if each category of words was well represented. We found that the eight selected joy words were judged as more related to joy ($M = 4.53$; SE = .08) than to anger ($M = 1.15$; SE = .05), [$t(7) = 47.71$, $p < .001$] or disgust ($M = 1.09$; SE = .02), [$t(7) = 47.89$, $p < .001$]. The eight selected anger words were judged as more related to anger ($M = 4.45$; SE = .06) than to joy ($M = 1.05$; SE = .01), [$t(7) = 47.56$, $p < .001$] or disgust ($M = 3.14$; SE = .27), [$t(7) = 5.06$, $p = .001$]. The eight selected disgust words were judged as more related to disgust ($M = 4.41$; SE = .12) than to joy ($M = 1.08$; SE = .02), [$t(7) = 24.06$, $p < .001$] or anger ($M = 2.09$; SE = .15), [$t(7) = 35.26$,

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$p < .001$]. Finally the 24 selected neutral words were judged as neither related to joy ($M = 1.57$; SE = .03), nor anger ($M = 1.31$; SE = .03) nor disgust ($M = 1.32$; SE = .03).

Two important questions were related to the arousing level of the words and to the impact of the musical primes on this perceived arousal. Therefore, we asked 23 new participants (mean age = 19.78, SE = .04, 91% female) either in the same happy music condition ($N = 11$) or in the same angry music condition ($N = 12$) as for the main study to assess the 48 target words for arousal on a scale ranging from 1 'relaxing, calm' to 7 'stimulating, activating'. The assessment of words was done while the music was played in the background in an identical way as during the main study. After completion of the arousal scales for the words, the music was stopped. Participants were asked to judge whether the music played in the room attracted their attention on a scale ranging from 1 'not at all' to 7 'very much'. The participants also rated the music for arousal using the same scale they used for judging the words. The results regarding the assessment of words showed that the music did not influence the arousal assessment (Angry music $M = 4.67$, SE = .10; Happy music $M = 4.51$, SE = .11), [$F(1, 21) = 1.06$, ns]. There was a main effect of words, [$F(1, 19) = 67.00$, $p < .001$] with angry words ($M = 6.39$, SE = .12) judged as more arousing than all the other words (all $Ps < .001$), disgust words ($M = 5.34$, SE = .14) were rated as more arousing ($p < .001$) than joy ($M = 3.16$, SE = .27) words and neutral words ($M = 3.49$, SE = .16). Neutral words and joy words did not differ from each other ($p > .20$). The interaction was not significant showing that the type of music displayed did not interfere with the arousal rating of the words, [$F(3, 19) = 1.63$, ns]. Turning to the assessment of the music, the results showed that the angry music ($M = 5.50$, SE = .38) was rated as more arousing than the happy music ($M = 2.55$, SE = .51), [$F(1, 22) = 22.04$, $p < .001$]. However, both music attracted participants' attention to the same extent (Angry music $M = 5.42$, SE = .40; Happy music $M = 4.73$, SE = .51), [$F(1, 22) = 1.17$, ns].

The results from the post-test are important since they show that the music did not influence the arousal ratings of the words. Any (in)congruency effects between words and music could therefore only be attributed to the matching with one specific discrete emotion. Importantly, joy words were not found to be more arousing than neutral words which confirms that any effects found with joy words should be related to the discrete emotion displayed rather than to arousal.

Measures

Toronto-alexithymia scale (TAS-20)

The TAS-20 is the most widely used measure of the alexithymia construct (Bagby, Parker, & Taylor, 1994; Bagby, Taylor, & Parker, 1994). It is comprised of 20 items that are rated on 5-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree). The items load on three factors—(a) difficulty identifying feelings (e.g. 'when I am upset, I don't know if I am sad, frightened, or angry'); (b) difficulty describing feelings (e.g. 'I find it hard to describe how I feel about people') and (c) externally oriented thinking (e.g. 'I prefer talking to people about their daily activities rather than their feelings'). The present study used a validated French translation of the scale (Loas, Parker, Otmani, Verrier, & Fremaux, 1997). Total scores range from 20 to 100 points.

Positive affectivity negative affectivity schedule (PANAS)

The PANAS is a 20-item scale which assesses general positive and negative mood states (Watson, Clark, & Tellegen, 1988). It consists of 10 positive (e.g. interested) and 10

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negative (e.g. guilty) emotional states rated on 5-point Likert-type scales ranging from 1 (not at all) to 5 (extremely). The PANAS is the most widely used scale for the assessment of current mood states. We used the French version in the present study (Gaudreau, Sanchez, & Blondin, 2006). Possible scores range from 20 to 100.

Procedure

Before starting the experimental session (computerized experiment) the participants filled out the PANAS questionnaire in order for us to obtain a measure of their initial emotional state. Then, they were presented with the experimental instructions on the computer screen. Stimuli were presented using E-Prime 1.1.4.1 on a 17-inch color monitor. The tasks used in Vermeulen and Luminet (2009) were utilised. In the 'shallow' condition, participants were instructed to indicate whether a pattern of 'C' for consonant and 'V' for vowel match the letter sequence of a word (e.g. CVCCVC for the word CANCER). The remaining participants performed the 'deep' task, in which they had to indicate whether the referent of each word was related to an emotion or not. In order to ensure a constant intensity of processing across participants, half of the words presented required a 'yes' answer ('S' key press) and the other half a 'no' answer ('L' key press). Response time and accuracy were recorded in order to analyse the way participants encoded the words. The 'S'/'L' response position was counterbalanced across participants and conditions.

During all the experimental sessions, music was discreetly played in the computer room through speakers located on each side of the laptop on which the experimenter was working. Nothing was said about the music to the participants, so no explicit judgment was made on the music before the end of the memory task. Therefore, the present procedure is very different from typical musical mood induction in which the music is explicitly displayed and the instructions focus the participants' attention towards the music and its associated to-be-felt emotion. In the present study, we simply present music in the background and the music is implicitly processed.

Depending on the condition, a 'happy' music or an 'angry' music was played. The music samples were selected on the basis of their use in previous research on mood manipulation. The happy music, which lasted about 6'31'' was 'Eine Kleine Nachtmusik' by Mozart. This music has been previously used to experimentally induce joy (Halberstadt and Niedenthal, 1997). The angry music, which lasted about 10'40'' was—'Night on Bald Mountain' by Moussorgsky. This music has been found to relate to anger and to fear (Mayer, Allen, & Beauregard, 1995). In the current experiment, each piece of music was repeated up to the end of the encoding stage. Once the encoding stage was completed, the music was stopped and the experimental session continued with the recognition task and questionnaires.

Then, as in Luminet *et al.* (2006), participants were presented with a surprise recognition task in which the encoded words were interspersed among an equal number of new neutral and emotion words. The list for the recognition task involved 48 new words with the same proportion of neutral and emotional words as for the list of the encoded words, i.e. 24 neutral and eight words per emotion category (joy, anger, disgust). Those new words that were only used for the recognition task were selected from the same pre-tested set of words and matched the encoded words for the discrete emotional content. During this recognition task, participants had just to decide whether the word they saw was presented before (Old decision) or if it was not presented before (New decision). The Old/New decision was made using the keyboard. Once the participants had completed the recognition task, they were

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asked to fill out the personality (TAS-20) and mood (PANAS for the second time) questionnaires (see measures section) as well as a manipulation check. In the manipulation check, the participants were asked to answer some questions about the music they heard by using a 7-point Likert scale ranging from 0 (not at all) to 6 (absolutely). The questions were, 'did the music disturb you?'; 'Did you appreciate the music?'; 'To what extent did the music make you feel happy?', 'To what extent did the music make you feel angry?; 'To what extent did the music make you feel sad?'; 'To what extent did the music make you feel aggressive?'; 'To what extent did the music make you feel fearful?'

Statitical analyses

We will first present analyses of the manipulation check questions related to the way participants processed the musical prime and the way the music influenced participants' mood.

We will then present analyses of the processing of the words using a dichotomous measurement approach of alexithymia. As has been done previously in alexithymia research (Suslow and Junghanns, 2002) and for the purpose of this general analysis, two alexithymia groups were considered based on a median split. The mean alexithymia score in the present sample was 47.11 (SE = 1.04) and the median value was 47. Two groups with significantly different scores were formed, [$t(106) = 16.69$, $p < .001$]: the low scorers ($N = 55$, Age: $M = 21.67$, SE = .35; 40 women) who had a score <47 ($M = 38.27$; SE = .82) and the high scorers ($N = 52$, Age: $M = 20.46$, SE = .25; 35 women) who had a score >48 ($M = 56.46$; SE = .71). Based on Taylor et al. (1997), people are considered as non-alexithymic[2] if their score is below or equal to 51. In the present study, 100% of the low scorers and 15% ($N = 8$) of the high scorers can be classified as such. A score from 52 to 60 represents moderate alexithymia levels. In the present study, 31 participants fall into that category and were all part of the high scorers group (59.6% of that group). Finally, we had 24.9% of the high scorers sample ($N = 13$) above or equal to the clinical threshold of 61. To sumarize, in the present study, 100% of the low alexithymia scorers can be considered as non-alexithymic whereas 85% ($N = 44$) of the high scorers are considered as moderately to highly (clinically) alexithymic. This result is highly comparable to the propotion we have found in larger samples (Luminet & Vermeulen, 2004; Vermeulen et al., 2006).

Using this median-split procedure, we tested whether (1) the encoding of joy words and angry words and (2) the recognition rates for joy words and angry words were affected by the levels of processing, type of musical prime and alexithymia level. We decided to use a median-split as a means to easily interpret the interactions between alexithymia, level of processing and musical prime.

For the recognition task, we computed correct recognition indices by subtracting false recognition rates (false alarms) from correct recognition rates (hits) to obtain a purer measure of memory performance. Then, those indices were transformed in order to obtain a percentage score (correct recognition indice of a category divided by the number of items presented in that category which was then mulitplied by 100). Analyses were then

[2]Taylor et al. (1997) explain that their TAS-20 cutoffs were fixed using the same methodology as in Taylor et al. (1988; p. 502) for the TAS-26. Based on clinical interviews in a sample of outpatients (with a fair interrater agreement among the three clinicians), the authors performed analyses to determine the best cutoff by identifying the most statistically conservative TAS score that maximizes the diagnistic validity of the TAS in identifying alexithymic and non-alexithymic people.

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computed on percentage scores. For instance, one participant who recognized correctly five joy words while making one false alarm on joy distractors would obtain a correct recognition indice for joy words of four (five hits minus one false alarm) and a percentage of correct recognition of 50% (four joy words divided by eight possible presented joy words).

RESULTS

Manipulation checks

We first analyzed how participants' mood (measured by the PANAS) was influenced by the musical condition. We ran an ANOVA with Music (Happy vs. Angry) as a between-subjects factor and mood (Positive affectivity vs. Negative affectivity) and time of measure (before encoding vs. after encoding) as a within-subject factor. Results showed that participants had significantly more positive affect ($M = 29.4$; SE = 0.64) than negative affect ($M = 14.93$; SE = 0.50), [$F(1, 105) = 296.64$, $p < .001$, $\eta^2 = .739$]. No other effects were present, showing that music had no influence on the mood state of the participants. Thus, the effects that are described below in this section cannot be explained by changes in the mood state of participants as a function of the musical priming procedure. Based on these results (see Table 1), the musical priming had no impact on the measure of alexithymia which is known to be a stable personality trait (Luminet, Bagby, & Taylor, 2001).

We then analysed how participants perceived and processed music by analyzing the manipulation check questions[3] (See Table 1 for a descriptive report of the four conditions). We ran an ANOVA with Music (Happy vs. Angry) and Alexithymia level (Low vs. High) as between-subjects factors and Emotional assessment (Joy vs. Anger) as a within-subject factor. The results showed that participants evaluated both pieces of music as inducing more happy feelings ($M = 3.00$; SE = .18) than angry feelings ($M = 1.27$; SE = .14), [$F(1, 103) = 44.10$, $p < .001$, $\eta^2 = .300$]. No other main effects emerged. However, the interaction between Music and Emotional assessment was significant, [$F(1, 103) = 28.30$, $p < .001$, $\eta^2 = .216$]. This interaction showed that participants evaluated the music excerpts as more related to happy feelings in the happy ($M = 3.66$; SE = .24) than in the angry ($M = 2.32$; SE = .27) music condition. The reverse was true for the question related to induced feelings of anger (anger music: $M = 1.96$; SE = .21; happy music: $M = 0.56$; SE = .19). No other interactions were significant. These results indicate that the participants processed the valence of the music excerpts in the expected direction. It is important to consider the relative effect of the music since the musical prime did not change the overall valence of participants' feelings. Indeed, our participants, independently of the music conditions, reported more happy feelings. This could be related to the fact that people had significantly more positive affect (PA) than negative affect (NA) when entering the laboratory (see Table 1). Once more, we would like to emphasize that the goal of the manipulation was not to change people's mood but to examine how music can

[3]We ran an analysis with all the manipulation check questions as repeated measures. As it is the case with the interaction involving only joy and anger, the results showed a main effect of the emotional question ($p < .001$), with participants assessing the music al pieces as more related to joy ($M = 2.98$; SE = .18) than to all other emotions (anger, sadness, aggressivity and fear, all Means < 1.51). Also, Music and Emotional assessment was significant, [$F(1, 103) = 15.08$, $p < .001$]. However, because all these effects were particularly driven by the interaction between joy and anger questions with the musical pieces, we decided in this report to more specifically present the interactions involving those questions.

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Table 1. Descriptive data of the participants as a function of the music condition and the level of processing condition

	Shallow level of processing(graphemic)		Deep level of processing(semantic)		
	Happy music ($N = 30$)	Angry music ($N = 24$)	Happy music ($N = 29$)	Angry music ($N = 24$)	F
Age	21.43 (2.58)	21.29 (2.03)	20.48 (1.48)	21.17 (3.03)	<1
Gendre ratio (M/F)	7/23	11/13	6/23	8/16	1.62
Alexithymia	46.93 (10.80)	48.17 (12.06)	46.38 (9.76)	47.17 (10.91)	<1
Positive affectivity					
pre-encoding†	28.97 (5.47)	30.71 (6.72)	30.07 (7.31)	27.42 (7.00)	1.11
post-recognition‡	28.57 (6.73)	30.08 (7.51)	31.79 (6.34)	27.25 (7.13)	2.15
Negative affectivity					
pre-encoding†	15.03 (5.12)	14.00 (4.02)	15.72 (5.40)	15.29 (5.79)	<1
post-recognition‡	15.17 (5.47)	14.71 (6.53)	15.14 (5.82)	14.42 (4.74)	<1
Happy feelings	3.37 (1.88)^{A}	2.29 (1.76)^{B}	3.97 (1.97)^{A}	2.33 (1.74)^{B}	5.21*
Angry feelings	0.43 (1.04)^{A}	1.75 (1.75)^{B}	0.66 (1.32)^{A}	2.21 (1.69)^{B}	9.19**

Note: Standard deviations are presented in parentheses.

$^{*}p < .01$; $^{**}p < .001$.

Capitalized letters present post-hoc comparisons across columns (i.e. by conditions). Differences were all significant at $p < .01$.

†Pre-encoding Affectivity corresponds to the first measure of the PANAS (before starting the computerized session).

‡Post-recognition Affectivity corresponds to the second measure of the PANAS (after the recognition session was completed).

serve as a priming manipulation that can affect memory performance. One possibility to explain these opposing findings between the PANAS and the manipulation check questions is related to the fact that the participants *retrospectively* assessed (during the manipulation check) the music as being related to a specific feeling. This might have forced them to retrospectively rely on their subjective feelings regarding the music in order to answer the questions but their feeling was not truly modified (as shown by the PANAS).

Encoding of words

Before analysing the way our experimental conditions affected word recognition, we first needed to examine how these conditions influenced the encoding stage (i.e. word processing). Therefore, we first entered Response times (RT) and Accuracy (ACC) in two ANOVAS with level of processing (perceptual vs. semantic), Music (Happy vs. Angry) and Alexithymia level (Low vs. High) as between-subjects factors and type of words (Joy vs. Anger) as a within-subject factor. Results showed that participants were slower, [$F(1, 99) = 449.89$, $p < .001$, $\eta^2 = .820$] but more accuracte, [$F(1, 99) = 8.19$, $p < .01$, $\eta^2 = 0.76$] during perceptual (RT, $M = 4339$ ms, SE = 109; ACC, $M = 91\%$, SE = 2) than during semantic (RT, $M = 1047$ ms, SE = 111; ACC, $M = 84\%$, SE = 2) processing. There was also an overall main effect of type of words found both in RT, [$F(1, 99) = 43.10$, $p < .001$, $\eta^2 = .307$] and in accuracy, [$F(1, 99) = 11.51$, $p < .001$, $\eta^2 = .104$] with participants

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processing joy words (RT, $M = 2481$ ms, SE = 87; ACC, $M = 90\%$, SE = 1) more quickly and more accurately than anger words (RT, $M = 2905$ ms, SE = 81; ACC, $M = 85\%$, SE = 2). Results from the accuracy analysis also showed a main effect of music, [$F(1, 99) = 8.13$, $p < .01$, $\eta^2 = .076$] with higher accuracy emerging in the angry music condition ($M = 91\%$, SE = 2) than in the happy music condition ($M = 84\%$, SE = 2). Interestingly, the four-way interaction depicted in Figure 1a appeared for accuracy, [$F(1, 99) = 4.84$, $p = .03$, $\eta^2 = .047$]. Decomposing this interaction showed that music, alexithymia and type of words interacted in the deep, [$F(1, 49) = 4.15$, $p < .05$, $\eta^2 = .078$] but not in the shallow processing condition, [$F(1, 50) < 1$, ns]. In other words, alexithymia influenced the (in)congruency between words and music only during semantic processing of words. More detailed analysis showed that the interaction between type of words and music observed in the deep condition was significant in high alexithymia scorers, [$F(1, 23) = 4.33$, $p < .05$, $\eta^2 = .158$] but not in low alexithymia scorers, [$F(1, 26) < 1$]. This latter result indicates that music facilitated the processing of words belonging to the same emotion category in the high alexithymia scorers but not in the low alexithymia scorers, thus confirming our hypothesis that high alexithymia scorers would have stronger (in)congruency effects. The results of the encoding stage demonstrated that music influences the encoding stage but that this only happened during the semantic (deep) processing condition and only for high alexithymia scorers.

Recognition of words

We analyzed *memory performance* by using an ANOVA with level of processing (perceptual vs. semantic), Music (Happy vs. Angry) and Alexithymia level (Low vs. High) as between-subjects factors and type of words[4] (Joy vs. Anger) as a within-subject factor. Results revealed a significant overall main effect of the level of processing condition on recognition, [$F(1, 98) = 62.57$, $p < .001$, $\eta^2 = .390$] with participants in the semantic processing condition recognizing ($M = 40.7\%$, SE = 3) a higher percentage of words than the participants in the perceptual processing condition ($M = 12.5\%$, SE = 3). Music had no main effect on recognition [$F(1, 99) = 1.35$, ns].

Turning to the moderating impact of alexithymia, there was also an overall main effect of alexithymia that supports our first hypothesis [$F(1, 99) = 3.98$, $p < .05$, $\eta^2 = .039$], with high alexithymia scorers recognizing fewer anger words and joy words ($M = 23.1\%$, SE = 3) than low alexithymia scorers ($M = 30.2\%$, SE = .03). Several interaction effects involving alexithymia level and music were observed. Alexithymia level interacted significantly with music (happy vs. Angry), [$F(1, 98) = 3.90$, $p = .05$, $\eta^2 = .038$]. As Figure 1(b) shows, no difference was observed between low ($M = 28.7\%$, SE = 3) and high ($M = 28.6\%$, SE = 4) alexithymia scorers in the happy condition, [$F(1, 57) < 1$, ns]. but low alexithymia scorers performed better ($M = 31.6\%$, SE = 4) than high alexithymia scorers ($M = 17.5\%$, SE = 4) in the angry condition, [$F(1, 47) = 6.97$, $p = .01$, $\eta^2 = .137$], thus supporting our second hypothesis that alexithymia would hamper memory performance in the angry music condition with an overall reduction of rates in high alexithymia scorers.

[4]We first ran a general analysis involving neutral words also but of course some results (like the main effect of alexithymia) disappeared. Importantly, for the recognition task the three-way interaction involving alexithymia, music and words was significant ($p = .01$) showing the (in)congruency effect for happy and anger words only. For the encoding task, words significantly interacted with music ($p < .05$) showing no effect of music on neutral words (Joy music: 91.6%; Angry music: 92.0%). Moreover, the four-way interaction already tended to be significant ($p < .10$).

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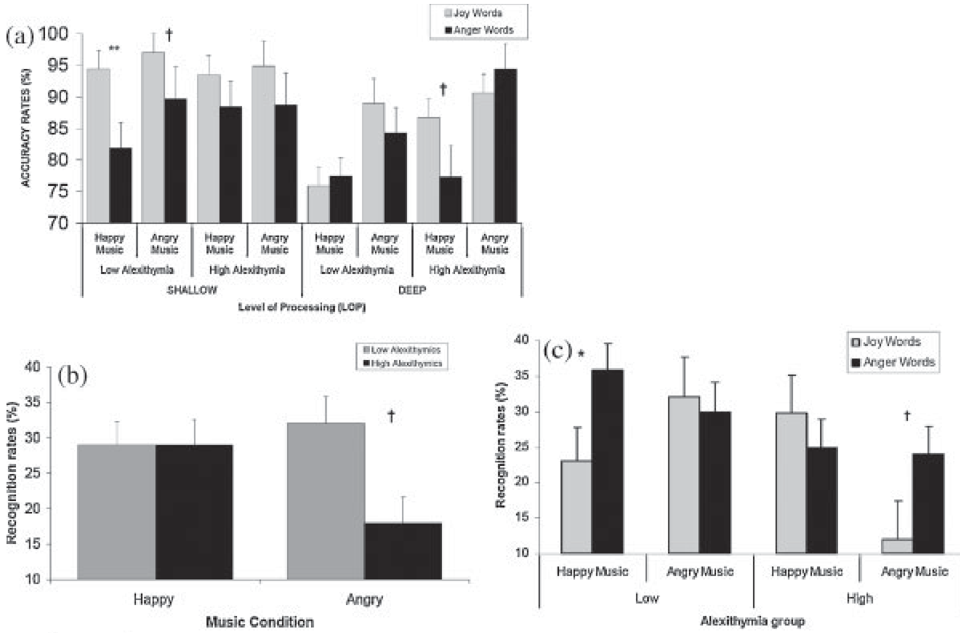

Note. † p < .06 ; * p < .05, ** p < .01

Figure 1. Mean (standard error) accuracy rates during encoding/processing of words (a) and recognition rates as a function of alexithymia level and music condition (b) and as a function of alexithymia level, music condition and type of words (c).

Importantly, the interaction involving alexithymia, music (happy vs. angry) and word type (Joy vs. Anger) was significant, [$F(1, 98) = 6.78$, $p = .01$, $\eta^2 = .065$] (Figure 1c). We decomposed this three-way interaction by analysing the interaction between words and music in each of the alexithymia groups. The results showed that the two-way interactions tended to be significant in the low alexithymia scorers, [$F(1, 53) = 3.57$, $p = .06$, $\eta^2 = .063$] as well as in the high alexithymia scorers, [$F(1, 49) = 3.65$, $p = .06$, $\eta^2 = .069$] but with a reversed pattern. Indeed, low alexithymia scorers recognized more anger words ($M = 35.9\%$; SE = 4) than joy words ($M = 23.0\%$; SE = 5) in the happy music condition but numerically fewer anger words ($M = 29.9\%$; SE = 5) than joy words ($M = 32.1\%$; SE = 6) in the angry music. Conversely, high alexithymia scorers recognized numerically fewer anger words ($M = 25.0\%$; SE = 5) than joy words ($M = 29.8\%$; SE = 6) in the happy music condition but more anger words ($M = 24.0\%$; SE = 5) than joy words ($M = 12.0\%$; SE = 6) in the angry music condition. These findings support our third hypothesis that high alexithymia scorers should present greater (in)congruency effects.

To better understand these latter effects, we computed a global facilitation index by subtracting incongruent trials (Anger words/Happy music and Joy words/Angry music) from congruent trials (Anger words/Angry music and Joy words/Happy music). A positive score means that participants show a facilitatory effect of music, whereas a negative score indicates that participants show an inhibitory effect. The data show that in the low alexithymia scorers group, 54.5% show an inhibition effect of music (negative score), 18.2% show no effect (score of 0) and 18.2% show a facilitatation effect (positive score). In the high alexithymia scorers group, 27.5% show inhibition, 23.1% show no effect and 49.0% show facilitation.

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An ANOVA showed that the facilitation index was significantly different in the high than in the low alexithymia scorers, [$F(1, 106) = 8.17$, $p = .005$, $\eta^2 = .073$], with low alexithymia scorers showing a global inhibition effect of music ($M = -8.5\%$; SE = 4) and high alexithymia scorers showing a global facilitation effect ($M = 8.4\%$; SE = 4). This latter finding support our view (third hypothesis) that a greater (in)congruency effect is observed in high alexithymia scorers.

Correlational analysis

We performed partial pairwise correlations between alexithymia, its three subscales and recognition rates, after controlling for the alternative variables (positive affectivity, negative affectivity). Since our previous analyses showed that music moderated the alexithymia effect, we ran correlations separately in the happy and in the angry music conditions. As shown in Table 2, across musical conditions, a negative correlation was found between alexithymia and its subscales and memory performances for anger words. Thus, supporting our second hypothesis of a processing deficit of anger in alexithymia, this correlation means that the higher the alexithymia score was, the worse the recognition rates for anger words were. Turning to specific musical conditions, analyses found that in the angry music condition, negative correlations were present between alexithymia and its subscales and recognition rates for joy words. These correlations suggest that the higher their alexithymia scores were, the less the participants recognized joy words. Importantly, in the happy music condition no such negative correlations were found and even a positive correlation involving the factor Difficulty Identifying Feelings (DIF) and recognition rates for Joy words was found (see Table 2). This association means that the more participants had difficulties in identifying feelings the more they were facilitated by the mere presence of the happy music as a cue to successfully recognize joy words. This gives an additional element of support to our third hypothesis of a greater (in)congruency effect in high alexithymia scorers.

Table 2. Two-tailed partial correlations between recognition rates and alexithymia total score, DIF, DDF and EOT when controling for positive and negative affectivity (PANAS)

Type of words	TAS-20	DIF	DDF	EOT
Angry music				
Neutral	−.018	−.083	.006	.065
Joy	−.430**	−.283†	−.440**	−.230
Disgust	−.088	−.034	−.182	.005
Anger	−.270†	−.245	−.262†	−.066
Happy music				
Neutral	−.079	.068	−.023	−.220
Joy	.174	.343*	.043	.016
Disgust	.023	.145	.101	−.182
Anger	−.245†	−.053	−.200	−.306*

DIF: first factor of alexithymia ‘difficulty to identify feelings’; DDF: second factor of alexithymia ‘difficulty to describe feelings’; EOT: third factor of alexithymia ‘externally oriented thinking’.
†$p < .10$.
*$p < .05$; **$p < .01$.

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DISCUSSION

In the present experiment, participants had to process emotional and neutral words at a perceptual or a semantic level of processing while either happy or angry music was discreetly played in the background in order to create (in)congruency effects. Results from our manipulation checks showed that participants retrospectively rated the music in the expected direction.

Using a median split, our analyses support our first hypothesis that high alexithymia scorers recognize fewer joy and anger words than low scorers. The present results are therefore consistent with previous findings showing an overall memory deficit for emotion words in alexithymia (e.g. Luminet et al., 2006; Suslow et al., 2003; Vermeulen & Luminet, 2009). The absence of an alexithymia effect on response time to words at encoding also supports the null findings in studies using response time to retrieve episodic memories (Lundh et al., 2002).

Confirming our second hypothesis, we found a moderating impact of alexithymia on the processing of anger. Indeed, we found that in the angry music condition low alexithymia scorers recognized more words than high alexithymia scorers. Collectively, the present research supports previous findings showing evidence for disturbed processing of anger either at a neural level (Meriau et al., 2006; Vermeulen et al., 2008) or at a behavioural level (Vermeulen et al., 2006). The present research extends those findings to word stimuli in a memory task. Moreover, whereas all of the previous studies found a deficit for the processing of anger stimuli, the present research also showed that discreetely played angry music is sufficient to interfere with encoding of emotional words in high scorers. Therefore, the present research shows that, in addition to a previously observed deficit in visual processing of anger related stimuli, high alexithymia scorers are also disturbed by a discrete auditory presentation of angry music in the background.

The decreased memory performance in the angry music condition for high alexithymia scorers could be related to the previously observed deficit in anger processing in alexithymia. (e.g. Vermeulen et al., 2006, 2008). This type of deficit has been related to poor awareness of environmental cues and to incorrect appraisal of events as emotion signals (Lane et al., 1996; Taylor, Bagby, & Parker, 1997). This type of effect is consistent with recent brain findings that found over-activation following threatening information processing in high alexithymia scorers (Meriau et al., 2006). From this point of view, our data along with previous findings support the hypothesis that anger disrupts cognitive processing of emotional information in high alexithymia scorers, resulting in the present study in a general decrease of memory performance in the angry music condition.

Importantly, supporting our third hypothesis, we found a three-way interaction involving alexithymia level, music and words on recognition rate. We hypothesized that low alexithymia scorers would automatically control the emotional context (irrelevant to the task) related to the music whereas high scorers would encounter more difficulties in disengaging their attention from the musical content. This interaction showed that the low alexithymia scorers did not use music as a cue for recognizing words whereas the high scorers seemed to be more influenced by music as a cue such that congruency and incongruency effects between music and words depended on a participant's level of alexithymia. High alexithymia scorers showed typical congruency–incongruency effects such that they recognized numerically more joy words than anger words in the happy music condition whereas they recognized more anger words than joy words in the angry music condition. Inversely, the low scorers recognized fewer joy words than anger words in the

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happy music condition. One possible interpretation is that when low alexithymia scorers inhibit the emotion conveyed by the music, they are less able to deeply access the emotional meaning of the words from the same discrete emotion. Of particular interest, this control or absence of control due to alexithymia over the emotional content of music was already observed during the encoding stage when participants had to assess the emotionality of the words. This means that the memory effects observed in the present study are at least partly related to individual differences at encoding. This is very interesting since the three-way interaction seems to be specifically related to a moderating impact of alexithymia on the processing of joy words, whereas anger words appear to be less influenced by this interaction between music and alexithymia level. Even if post-hoc contrasts did not show any significant difference between high and low alexithymia scorers, the correlations confirm that this positive influence of happy music on the retrieval of joy words was influenced by alexithymia level. Indeed, an original finding from this study is that the factor DIF was positively associated with memory performance for joy words in the happy music condition. This points to the fact that a happy cue at encoding could help people having difficulties ! in identifying feelings to encode and retrieve positive information. Regarding the differential effects of the three factors, our correlational findings showing a stronger association for the 'emotional factors' of alexithymia (DIF and DDF) is consistent with past literature, which suggests that the factor 'difficulty in identifying feelings' (DIF) and the factor 'difficulty in describing feelings' (DDF) would be associated with poor memory performance for emotional words (Suslow, Kersting, & Arolt, 2003). Inversely, the cognitive factor 'externally oriented cognitive style' (EOT) of alexithymia is supposed to be less or not at all related to memory performance for emotional words.

The literature regarding memory and alexithymia is quite new and as presented in our introduction only a few papers have been published on this topic. Most of those published studies (except Lundh et al., 2002) found that alexithymia negatively influenced memory functioning for emotional material. These studies also showed that alexithymia did not alter the processing of non-emotional material. Any deficit in memory functioning in high alexithymia scorers cannot be attributed to a general memory deficit in those individuals. Importantly, this deficit was specifically explained by variations in alexithymia scores and not by alternative variables like anxiety or depression. The novel contribution of the present paper is that providing a contextual cue at encoding (such as a musical cue) might help high alexithymia scorers to better encode emotional information in order to reduce the deficit in memory functioning for affective events. This is particularly important since it leaves open new lines of research that could aim at examining the way clinicians and practitioners might provide support to high alexithymia scorers in order to better process, encode and retrieve (personal) emotional events. Our data support findings showing that the influence of alexithymia can be reduced by four-month-long group psychotherapy treatment involving, in part, music and guidance in identifying feelings (Beresnevaite, 2000). Therefore, the present research, by showing that the deficit in cognitive processing of emotional information can be modified, supports the view that alexithymia can be changed and its impact reduced (Gay, Hanin, & Luminet, 2008; Grabe et al., 2008; Lumley, Neely & Burger, 2007).

Future studies examining the effect of alexithymia on memory should seek to overcome some methodological limitations of the current work. First, the fact that we used angry and happy music conditions did not allow us to rule out the possibility that the influence of music on cognitive processing of emotion words is related to an arousing or attention

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effect. Our post-test partly confirms this limit as the angry music was found to be more arousing than the happy music. However, these results also suggest that the angry music did not attract more the participants' attention than the happy music. Therefore, if our predicted congruency–incongruency effect is truly based on discrete emotions (i.e. anger vs. joy) then we should not find this congruency–incongruency effect when using other high arousing or negatively valenced music. Moreover, we did not consider a measure of musical expertise of our participants; it is possible that musical expertise could have influenced our results. This possibility could be investigated in future research. A second limitation is related to the fact that the angry music we used also involved fear (as Mayer et al., 1995 previously found) but this difficulty is also found elsewhere. The proximity between anger and fear has been found in domains other than music. The circumplex model of affect proposed by Russell (1980) places both threat- and fear-related words (i.e. angry, afraid) in the same part of the model (Low pleasure, High arousal). In addition, Öhman (2002) suggests that hyper-sensitivity of the amygdala to fearful and angry faces reflects an evolved cognitive bias to discriminate threatening from non-threatening individuals. From this perspective, fear and anger are related to threat management and are thought to depend on a 'fear-system' located in the amygdala. The study by Scott *et al.* (1997) with auditory stimulations also confirms that this area of the brain (Bilateral amygdala) plays a crucial role for recognition of fear and anger through the auditory channel. Therefore, it seems difficult to disentangle anger from fear during emotional assessment (for further discussion on this topic see Carver and Harmon-Jones (2009) but also comments on this paper by Tomarken and Zald (2009) or Watson (2009)). Third, if words were different in their emotional content, they could also differ on other dimensions like arousal. This assumption was partly confirmed by our post-test that showed that angry words were more arousing than joy words. However, joy words were not more arousing than neutral words, which suggests that, at least for joy words, the observed moderating impact of alexithymia was not related to arousal but to the discrete character of the emotion. From this point of view, it is still possible that the effect we attribute to the emotional content of angry words is partly due to an arousing effect of those words. Very importantly, the post-test showed that the music priming had no influence on the arousal's assessment of the target words. This finding supports the assumption that the congruency–incongruency effects cannot only be attributed to differences in arousal. Finally, rather than splitting our sample at the median into low and high scorers, it could be more ecological to use the previously described cut-offs (i.e. non-alexithymic TAS-20 < 51; moderately alexithymic TAS-20 range $= 52$–60; clinical threshold TAS-20 > 61). In the present sample, such analyses were not feasible due to the small sample size. Indeed, as presented in the method section, only 13 participants in the whole sample scored equal or above the clinical threshold of 61. Future studies using larger sample sizes or pre-selecting participants on the basis of their alexithymia score could examine whether the memory of participants scoring below the clinical threshold differs qualitatively from the memory of people scoring above the clinical threshold.

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