Alexithymia disrupts the beneficial influence of arousal on attention: Evidence from the attentional blink

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Abstract

Alexithymia is a multifaceted personality construct which encompasses difficulties in identifying and describing feelings along with an externally-oriented cognitive style. The influence of alexithymia and arousal on the cognitive processing of emotion is now widely demonstrated. In order to test the joint influence of alexithymia and arousal on attentional processes, 55 participants completed two blocks of attentional blink (AB) trials, one after a baseline (relaxed) session and the other after a cycling (aroused) session. The AB task consists in presenting a neutral first to-be-detected target (T1) and second targets (T2) that were either neutral (e.g., Echo), low arousal (i.e., Emptiness) or high arousal (e.g., Murder) words and presented 213 ms after T1. The results show that alexithymia interacted with arousal (cycling vs baseline) and type T2 so that arousal was beneficial to detect T2 only for low alexithymia scorers. The findings are discussed within the framework showing a decoupling between physiological arousal and subjective experience in high alexithymia scorers.

Words count: 159 words

1.**Introduction**

In the circumplex model of affect (Russell, 1980), emotions are structured as a linear combination of the positivity-negativity dimension called valence and the dimension of arousal, indicating whether an emotion or stimulus is rather exciting (or activating) or calming (or relaxing). In the literature, a growing body of evidence suggests that emotions influence the way we pay attention to and perceive our environment. More precisely, emotional values of perceived stimuli influence their processing. For instance, humans preferentially detect emotional faces based on visual saliency of specific affective features (Calvo and Nummenmaa, 2008; Mermillod et al., 2009). As well, neuroimaging and neurophysiological studies found that processing fearful expressions increased neural activity in areas involved in attentional networks (Anderson et al., 2003). Collectively, these researches showed that emotional content of stimuli, and particularly arousal, boosts their processing. At a behavioral level, some researchers used the attentional blink paradigm (AB; Raymond, Shapiro, & Arnell, 1992) to examine modifications of attention to emotional stimuli. In rapid serial visual presentation (RSVP, with more than 10 items per second), AB refers to the deleterious effect of the first target (T1) identification on the accuracy of the second target (T2) identification when T2 appears within a period of 200-500ms following T1 onset (Raymond et al., 1992). In other words, when people have to report two targets quickly and briefly presented among distractors, they will often be unable to consciously report the second target (T2) once they accurately reported the first target (T1).

By using this AB paradigm, many researchers found that emotions moderated the AB (Anderson, 2005; Vermeulen et al., 2009a; Kever et al., 2015). For instance, across five experiments, Anderson (2005) found, using mainly arousing taboo words, enhanced report of arousing T2 words (e.g., Orgasm, Fear) compared to neutral T2 words (e.g., Point). This author demonstrated that it is the arousal level of words rather than their valence that impacts attention. The studies thus suggest that when stimuli possess arousing characteristics they will better resist the typical attentional blink. One intriguing question that follows is related to the arousal body state modification in perceivers. Previous research indeed showed that perceivers' physiological arousal indices (e.g., heart rate) increased following the processing of arousing stimuli (Lang et al., 1993). Similarly, in different research areas, like sexual arousal ratings or affective pictures processing, it was shown that increasing arousal through physical exercise modified emotional responding to emotionally arousing events (Meston and Gorzalka, 1995; Crabbe et al., 2007). This influence of physiological arousal on the processing of arousing stimuli was also observed in the attentional domain using the AB paradigm (Kever et al., 2015). Therefore, collectively, the literature showed fascinating interactions involving arousal of the stimuli and physiological arousal.

One intriguing question relates to individual differences in emotion processing. Is it possible that impairments in emotion labeling disrupt the above-mentioned relationship between arousal and attention. We predict that individual differences in emotional awareness and responding, like Alexithymia, could disrupt this arousal-induced modification of attention. Alexithymia is assumed to be a relevant personality trait in this perspective since it encompasses: (1) difficulty identifying feelings and distinguishing between feelings and the bodily sensations of emotional arousal; (2) difficulty describing feelings to others; and (3) a stimulus-bound, externally-oriented cognitive style (Taylor and Bagby, 2004). Alexithymia affects the way physiological arousal influence subjective or conscious access to emotional responding (Taylor and Bagby, 2004). Importantly, numerous studies found that alexithymia impaired the cognitive processing of emotional visual information like emotion words or facial expressions (Franz et al., 2004; Mueller et al., 2006; Vermeulen et al., 2006; Vermeulen et al., 2008; Vermeulen and Luminet, 2009), as well as auditory information like spoken sentences, prosody and even non verbal vocalizations (Bayot et al., 2014). For Taylor and Bagby (2004), alexithymia might be related to a deficit in the ability to link somatic sensations of emotional arousal to symbols like words or images. However, a recent literature review shows also that the physiological findings are mixed and, even if there are many contradictory evidence, physiological findings in alexithymia tend to show hypo-reactivity during emotion processing (Panayiotou, Panteli, & Vlemincx, 2018). This is consistent with the view that alexithymia represents a deficit that might be specific to the processing of arousing characteristics of emotions (Panayiotou et al., 2018). Interestingly, neuroimaging studies showed evidence of neural dysfunctions in alexithymia in a large emotion network. This emotional network is involved in attention, awareness, emotional experience or emotional learning and includes amygdala, cingulate, insula, and the prefrontal cortex (Goerlich & Aleman, 2018). Collectively, these findings are consistent with the recently proposed attention-appraisal model of alexithymia (Preece, Becerra, Allan, Robinson, Dandy, 2017). In this emotion regulation model of alexithymia, Preece *et al*. (2017) suggest a four stage *Situation-Attention-Appraisal-Response* valuation system, whereby a single stimuli, a more complex event, or even an emotional response is evaluated (valuated) regarding its personal significance. Following Preece *et al*. (2017), alexithymia might represent a deficit in the attention and appraisal stage of this valuation system. At the attention level of this valuation model, once an emotional response occurred, high alexithymia scorers have difficulties focusing their attention on it. At the appraisal stage, alexithymic people present difficulties appraising what the emotional response is and what is its signification. In this model, Preece et al. (2017) suggest that alexithymia can occur due to poorly organised or integrated emotion schemas, what they call ability deficit. However, alexithymia may also represent an avoidant emotional regulation strategy. This deficit occurs at the emotional response stage of the valuation (of stimuli) system. Avoidance alexithymia can be observed when people avoid focusing their attentional resources on the emotional response (attention stage) or when people avoid integrating current input about a stimulation (appraisal stage) to their emotion schemas. In other words, ability deficits relate to the poorly integrated emotion schemas in high alexithymia scorers. With underdeveloped schemas, people are unable to focus adequately their attention to the most important aspects of their emotion response (attention stage) but they can also hardly differentiate or interpret the patterns of information about their emotional response in order to create a specific evaluation (e.g., I feel angry) rather than a diffuse or general one (e.g., I am upset). Avoidance deficits are related to the emotion regulation strategy used in alexithymia. Such deficit in linking somatic arousing sensations to symbols may account for the decoupling effect previously observed between a reduced subjective emotional experience and increased arousal responses (Luminet et al., 2004). Indeed, these authors demonstrated that high alexithymia scorers assess emotional films as less intense together with increased (i.e., higher) cardiovascular (HR) responses (Luminet et al., 2004). In other words, such findings showed that their own increased arousing response to emotional events did not help them to adequately assess those stimuli.

The present study aimed at addressing this question by examining the influence of alexithymia on the effect of arousal on attention by using the AB. We modified the physiological arousal of our participants by asking them to first relax (in order to obtain a baseline) during 5:30 minutes and then to cycle during 5:30 minutes on an exercise bike at a moderate heart rate of 110 beats per second (Salmela and Ndoye, 1986). After both the relaxation session and the cycling session, participants were immediately invited to complete a block of AB trials in which they had to detect neutral, low arousal and high arousal target words. None of the words were taboo words. Importantly, because previous AB studies (e.g., Anderson, 2005) revealed better performance for high arousing T2, the present study aimed to replicate this later effect by directly comparing high arousal words (T2) to low arousal words (T2). We hypothesized that participants would report more high arousal words than low arousal words. We also hypothesized that alexithymia would disrupt the influence of arousal on attention to words. Because of this decoupling between arousal activation and subjective experience, and based on the hypo-activation model in alexithymia, we hypothesize that arousal may influence AB performance in low alexithymia scorers only. In this view, we hypothesize that high alexithymia scorers may be less influenced by the arousal level of words and would not show the typical word arousal-bias in the AB (Anderson, 2005).

2. Methods

2.1. Participants and materials

Fifty-five French speakers participants (Age: *M* = 22.29; *SD* = 2.87) were tested individually. All had normal or corrected-to-normal vision. A set of 144 non emotion-related (i.e., neutral) French words was selected from previous attentional blink studies (Vermeulen et al., 2009ab;). These words were neither related to emotion valence, not arousal (e.g., *ECHO*, *SALT*, *THEORY*, *DEEP*, *PAPER*). All the T1 and one third of the T2 were selected from this pool of neutral words. We also created two lists of emotion words (Low arousal vs. High arousal) that were rated for arousal and subjective language frequency by 20 independent raters who did not participate to the study (50% women; Age: *M* =22.85; *SD* = 7.92). Thirty-six low arousal and 36 high arousal words were selected from a list of 201 rated words. For arousal, judges had to rate each word on a 7-point Likert scale ranging from 1 (Calming, Relaxing, Alleviating) to 7 (Arousing, Exciting, Stimulating). Also, the words were rated for subjective frequency of use on a 10-point Likert scale ranging from 1 (never used) to 10 (frequently used). Results of the pre-test showed that the 36 selected high arousal words were rated as more arousing (*M* = 5.85; *SD* = .35), $F\ (1, 71) = 723.62$, $p< .001$, but equally frequent (*M* = 5.95; *SD* = 1.48); $F\ (1, 71) < 1.00$, *ns)*, than the 36 selected low arousal words (Arousal: *M* = 2.53; *SD* = .65; Frequency: *M* = 6.02; *SD* = 1.81).

Seventy-two pairs of targets (T1-T2) were created. The 72 T1 were neutral and 24 T2 were neutral, 24 were emotion-related low arousal words (e.g., *RELAX, BEACH, EMPTINESS*) and 24 were emotion-related high arousal words (e.g., *HATRED, WAR, PASSION*). There were thus a total of 72 trials. The two targets were composed of 4 to 7 letters and were matched for length. All stimuli (T1, T2 and distractors) appeared in a same stream of stimuli (one stimulus replacing another in the centre of the screen). The distractors were comprised of random strings of symbols and digits of the same length as the words on each trial (e.g., $,£, *, &, 6, @). Target words appeared in uppercase letters. All stimuli (distractors and targets) were black, presented on a white background, and all items were presented in Courier New 18-point bold font.

2.2. Procedure

Upon their arrival in the experimental room, each participant received instructions explaining them the main task (AB). Before starting the experimental blocks, participants receive a training block of trials (not used in the experimental blocks) allowing them to familiarize with the AB paradigm. They were then explained that before completing the first block (baseline) they would first engage in a relaxation session for about five minutes. Once this first baseline block was completed, they were invited to cycle during five minutes before starting the second experimental block. They were explained that this cycling session was proposed in order to distract between the two experimental blocks of trials. Then, they completed the second (arousing) experimental block of AB trials and finished the session by completing the Toronto Alexithymia Scale 20 items (TAS20; Bagby, Parker & Taylor, 1994) questionnaire in its French version (Watters, Taylor, Ayearst, & Bagby, 2019).

In the relaxation session, participants we comfortably sat in an armchair while listening to an audio program in which a man was describing slowly and calmly a landscape. This baseline session lasted 5:30 minutes.

In the cycling stage, participants sat on an exercise cycle, the Pro-form 748 EKG model (produced by ICON Health & Fitness, Ltd.), and put their hands on a handgrip pulse sensor allowing for the precise measure of current hart rates. The experimenter selected the target heart rate of 110 beats per minutes and the participants started to cycle until achieving the target heart rate. The participants were instructed to maintain this moderate level until the 5:30 minutes of cycling were completed. The experimenter stayed near the exercise cycle to ensure the participants maintain this target heart rate.

Each AB trial started with the presentation of a fixation cross directly followed by the RSVP of distractors and targets. The presentation duration was set to 53 ms/item The stimulus onset asynchrony (SOA) between the two target words was set to 213 ms as there was always three distractors between T1 and T2. There were three to five distrators before the presentation of T1, and T2 was always followed by two distractors. Within a trial, the same distractor was never repeated. After each RSVP, participants were instructed to type the first word they saw in the RSVP trial (T1), followed by the second word they saw (T2). The next trial started 1000 ms after the decision on the second target was made.

Stimuli were presented using E-Prime 1.1.4.1 on a Dell PC with Processor Intel-Pentium IV 2.3 GHz/256Mb SDRAM computer with a 17-in. monitor with a refresh rate of 75 Hz. The participants read computer-presented instructions. The task was to detect and report (using the keyboard) the two words that appeared among the distractors. Misspelled words and blanks were counted as errors (Davenport and Potter, 2005).

All participants completed the Toronto-Alexithymia Scale 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 -- difficulty identifying feelings, difficulty describing feelings; and externally oriented thinking. Total scores range from 20 to 100 points with higher scores indicated higher levels of alexithymia. The study received an approval from the IPSY ethics committee.

3. Results

Overall, 62.9% of the words were reported accurately, which corresponds to slightly more than one word per trial (on two possible words). Consistent with previous studies (Davenport and Potter, 2005; Vermeulen et al., 2009b), there was a significant main effect of Target position (AB effect), $F(1, 54) = 184.62$, $p< 0.001$, $h^2= .774$, with T1 reported more accurately ($M = .86$; $SE = .01$) than T2 ($M = .37$; $SE = .04$). We do not present T1 analyse since no effect of the arousing condition, of the type of T2 and no interaction between these conditions was significant in the accuracy of T1 report.

In order to examine whether T2 performances would be influenced by arousal and alexithymia, an analysis of variance (ANOVA) was first used to analyze the accuracy of reporting T2 with a 2 (Arousing condition: Baseline vs. Cycling) x 3 (Type of T2: Neutral vs.

Low arousal vs. High arousal words) and the alexithymia total score entered as a continuous covariate. Results revealed a significant three-way interaction involving arousing conditions, type of T2 and the total scores of alexithymia, $F(2, 52) = 3.47$, $p< 0.04$, $h^2= .118$. No main effect of alexithymia was observed, $F(1, 53) < 1$, ns. The main effect of type of T2 did not reach significance, $F(2, 52) = 2.08$, $p = .13$, $h^2= .074$ because accurate report of Neutral T2 ($M = .394$; $SE = .04$) was not significantly lower than accurate report of high arousal T2 ($M = .416$; $SE = .04$), $t(54) = 1.097$, $p > .25$ or significantly higher than accurate report of low arousal T2 ($M = .380$; $SE = .04$), $t(54) <1$, $p > .40$. However, paired t-test confirmed that high arousal T2 were significantly better reported than low arousal T2, $t(54) = 2.138$, $p = .037$. Moreover, as illustrated in Table 1, there was a main effect of condition showing that participants reported significantly more T2 after cycling than after being relaxed, $F(1, 53) = 5.38$, $p= 0.02$, $h^2= .092$. The interaction involving condition and type of T2 was marginally significant, $F(2, 52) = 2.63$, $p= 0.08$, $h^2= .082$. But Table 1 also shows that, when the same ANOVA was ran without alexithymia as covariate, the main effect of the arousing condition was increased compared to when alexithymia was entered as covariate in the model, thus confirming that alexithymia significantly influenced the effect of arousing condition (R^2 change = .154).

In order to better understand this influence of alexithymia on the interaction between arousing condition and type of T2, participants were classified and separated as high versus low in alexithymia scorers based on a median-split of the questionnaire measure. The mean alexithymia score in the present sample was 45.38 (SD = 9.59) and the median value was 47. Two groups with significantly different scores were formed, [$t(53) = 10.33$, $p < .001$]: the low scorers (N = 28) who had a score ≤ 47 ($M = 37.75$; $SD = 6.46$) and the high scorers (N= 27) who had a score ≥ 48 ($M = 53.30$; $SD = 4.48$).

Then two new analyses of variance (ANOVA) were ran separately in the two Alexithymia groups to analyze the accuracy of reporting T2 with a 2 (Arousing condition: Baseline vs. Cycling) x 3 (Type of T2: Neutral vs. Low arousal vs. High arousal) As can be observed in the Figure , the results revealed among low alexithymia scorers a main effect of arousing condition, $F(1, 27) = 20.88$, $p< 0.001$, $h^2= .436$ which indicates that low scorers reported more T2 after cycling than after relaxing (Figure 1a). The results also showed a main effect of type of T2, $F(2, 26) = 4.06$, $p = 0.03$, $h^2= .238$ which indicates that low scorers reported significantly more high arousing T2 (M = .449; *SE* = .06) than low arousing T2 (M = .377 *SE* = .06), $t(27) = 2.87$, $p = .008$ and tended to report more high arousing T2 (M = .449; *SE* = .06) than Neutral T2 (M = .404 *SE* = .06), $t(27) = 1.76$, $p = .089$ (Figure 1b). Reports of Low arousing T2 and Neutral T2 were not statistically different, $t(27) = 1.04$, $p = .30$. No interaction between arousing condition and type of T2 was observed in low scorers, $F(2, 26) < 1$, *ns* (Figure 1c).

In contrast, in high alexithymia scorers, there was neither a significant main effect of arousing condition (Cycling: *M* = .404; *SE* = .06; Relax: *M* = .362 *SE* = .05;), $F(1, 26) = 2.37$, $p = .14$, $h^2= .08$ nor a main effect of type of T2 (high arousing T2 : *M* = .382; *SE* = .06; than low arousing T2 :*M* = .384 *SE* = .06; Neutral T2: *M* = .384 *SE* = .06), $F(2, 25) < 1$, *ns*. However, as illustrated in Figure1c, a significant interaction between arousing conditions and type of T2 was found, $F(2, 25) = 4.46$, $p = .02$, $h^2= .263$. Further *t*-tests showed that in the high scorers group, cycling condition compared to baseline only improved reports for neutral T2 of about 12 percents (Cycling Neutral T2 :*M* = .443 *SE* = .07; Relax Neutral T2: *M* = .326 *SE* = .05), $t(26) = 3.18$, $p = .004$, whereas high and low arousal words remained statistically unaffected by arousing conditions, both $t(26) < 1$, *ns*.

4. Discussion

In two different manipulations in a within-participant design, we both relaxed and aroused (cycling) participants. After each condition, participants were immediately invited to complete a block of Attentional Blink in which they had to detect neutral, low arousal and high arousal target words. We hypothesized that participants would report more high arousal words than low arousal words. We also hypothesized that high alexithymia scorers may be less influenced by the arousal level of words and would, therefore, not show the typical word arousal-bias in the AB (Anderson, 2005).

We found that arousal level of stimuli as well as arousal states of our participants play a crucial moderating role on attentional focus. We first found that increasing (physiological) arousal of participants led to improved reports of T2 words. We also found that high arousal T2 words were better reported than low arousal T2 words which confirms previous findings (Anderson, 2005). Importantly, as expected, we found that the alexithymia levels of our participants affected these effects. The results showed that only low alexithymia scorers demonstrated a main effect of arousal of words and a main effect of arousing condition. Whereas we expected a significant interaction between arousal and alexithymia, the present results are in line with the literature. Indeed, alexithymia has been shown to be associated to a disconnection between higher arousal (heart rates) responses to emotional stimuli and lower proportion of emotional words they used when high scorers described their feelings (Luminet et al., 2004). Together with the present results, these later findings may support the theoretical assumption that alexithymia may be related to an inability to link emotional arousal responses to symbols like words (Taylor & Bagby, 2004). Such finding thus raises a crucial issue related to very selective arousal influence on the access to awareness in alexithymia. Indeed, in high alexithymia scorers, the awareness (i.e., conscious report of targets) enhancement works only when non-emotional words were detected but is flattened as soon as emotional words are encountered.

These findings may appear coherent with the recently proposed attention-appraisal model of alexithymia (Preece *et al.,* 2017). This model claims that alexithymia represents a deficit during attention stage and appraisal stage of emotion regulation processes which can be represented by an ability deficit (i.e., poorly integrated schemas) and an avoidance deficit. When using avoidance people may avoid focusing their attention on the emotional response (attention stage) or people may avoid creating linkage between the stimulation, their emotional response and their existing schemas. In the present study, both avoidance and ability deficits might be involved. Indeed, high scorers did not show an arousal effect but rather showed an interaction between arousing conditions and type of T2 words. This means that high alexithymia scorers, due to their ability deficit, did not adequately pay attention to the arousing properties of the emotion words. Importantly, adding alexithymia as a covariate showed that in high alexithymia scorers, the arousing condition (baseline versus cycling) had restricted influence as it worked only for neutral words. This finding appears interesting since it confirms, on the one hand, that high alexithymia scorers have deficits in emotional processing since they did not present a typical effect of arousal of T2 but, on the other hand, it confirms that they nevertheless were affected (i.e., aroused) by the arousal manipulation since the accuracy of Neutral T2 report was significantly increased following the cycling session compared to baseline. Due to their avoidance deficit high alexithymia scorers may not link adequately an emotional response to appropriate existing schemas. This is also in line with the idea that alexithymia represents essentially an arousal deficit (Panayiotou et al., 2018).

Importantly, some limitations of our results should be considered in future studies. For instance, even if we controlled the heart rate of our participants on-line during the cycling session, futures studies could measure subjective (i.e., arousal and emotional feelings) reports after each session as it would be very interesting to check if high alexithymia scorers feel emotionally aroused once the cycling condition in completed. Following the study by Luminet et al. (2004), we could hypothesize lower subjective reports in high alexithymia scorers compared to low alexithymia scorers. Finally, it could be argued that our effect of arousal modification (baseline vs cycling) could be due to a training effect since the cycling session always followed the baseline session. However, previous findings showed that participants' performances slightly improved or even the performance declined with time (Block 1 vs Block 2) in the attentional blink (Olivers and Nieuwenhuis, 2006). Then, although we cannot refute this possibility, our arousal modification effect (baseline vs cycling) can hardly be accounted for by a simple training effect.

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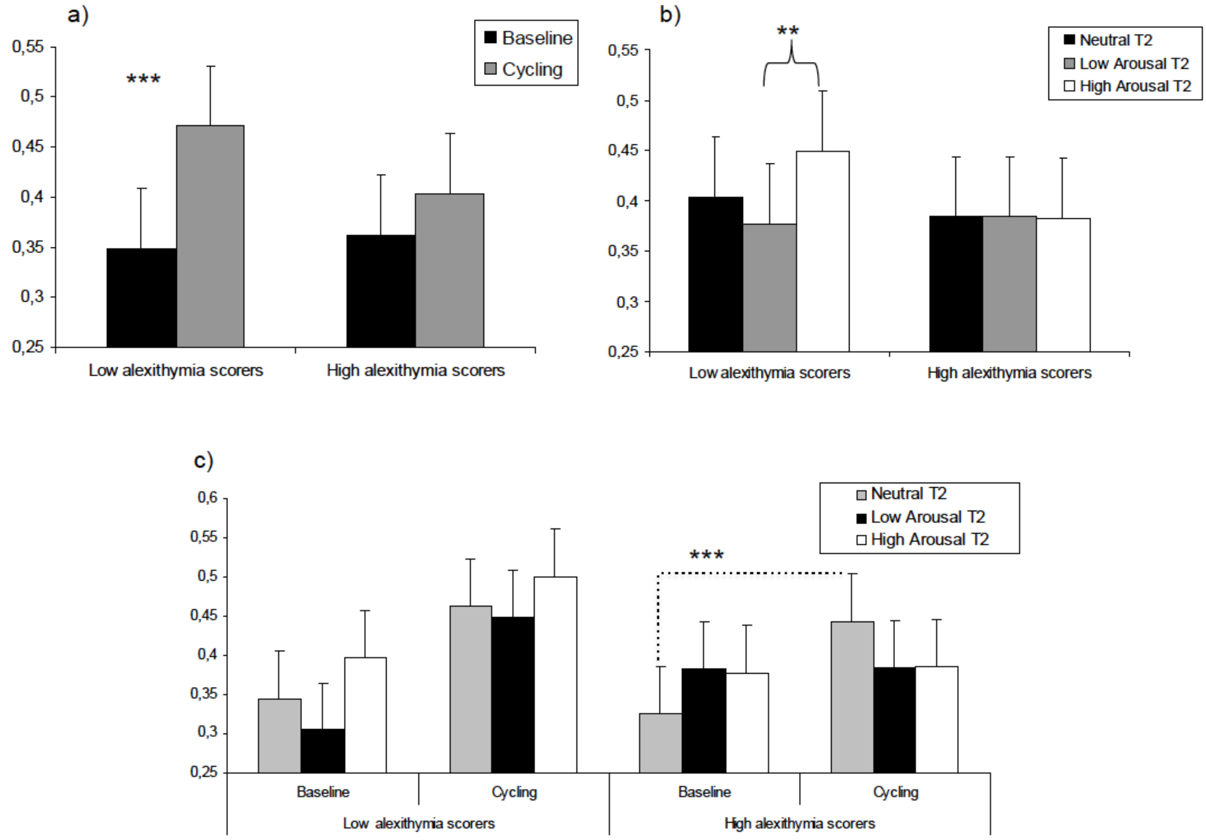
Figure captions

Figure 1. Proportions of correct T2/T1 reports (Means and SE) as a function of the interaction between alexithymia levels and arousing conditions (a), alexithymia levels and type of T2 (b), and alexithymia levels, arousing conditions and type of T2 (c)

Table 1

	Without alexithymia			Alexithymia as covariates			
Variables	*F*	*p*	R^2	*F*	*p*	R^2	R^2 *change*
Arousing condition	17.62	< .001	.246	5.38	.02	.092	.154
Type of T2 words	2.26	<.12	.078	2.08	.14	.040	.038
Arousing X T2 words	2.17	.12	.076	2.63	.08	.092	.016

Figure 1



Note. ** $p < .01$; *** $p < .001$