Running head: AUTOMATIC PROCESSING AND ALEXITHYMIA

Alexithymia and the Automatic Processing of Affective Information: Evidence from the Affective Priming Paradigm

Nicolas Vermeulen

Catholic University of Louvain at Louvain-la-Neuve, Belgium

Olivier Luminet

National Fund for Scientific Research

Catholic University of Louvain at Louvain-la-Neuve, Belgium

Olivier Corneille

Catholic University of Louvain at Louvain-la-Neuve, Belgium

Correspondence: Olivier Luminet, University of Louvain, Department of Psychology, Research Unit for Emotion, Cognition, and Health

10, Place Cardinal Mercier, B-1348 Louvain-la-Neuve, Belgium

e-mail to Olivier.Luminet@psp.ucl.ac.be

Abstract

In a first study, we examined the moderating impact of alexithymia (i.e., a difficulty identifying and describing feelings to other people and an externally-oriented cognitive style) on the automatic processing of affective information. The affective priming paradigm was used, and lower priming effects for high alexithymia scorers were observed when congruent (incongruent) pairs involving nonverbal primes (angry face) and verbal target were presented. The results held after controlling for participants' negative affectivity. The same effects were replicated in Studies 2 and 3, with trait-anxiety and depression entered as additional covariates. In Study 3, no moderating impact of alexithymia was found for verbal – facial pairs suggesting that the results cannot be merely explained in terms of transcoding limitations for high alexithymia scorers. Overall, the present results suggest that alexithymia could be related to a difficulty in processing and automatically using high arousal emotional information to respond to concomittant behavioural demands.

Alexithymia and the Automatic Processing of Affective Information: Evidence from the Affective Priming Paradigm

Over the past decade, the personality construct of alexithymia has gained increasing attention as a possible vulnerability factor for a variety of medical and psychopathological disorders (Kauhanen, Kaplan, Cohen, Julkunen & Salonen, 1996; Taylor, Bagby & Parker, 1997). The salient features of the construct include: (1) difficulty identifying feelings and distinguishing between feelings and bodily sensations of emotional arousal, (2) difficulty describing feelings to other people, (3) a reduced capacity to engage in fantasy and other imaginal activities, and (4) a stimulus-bound, externally-oriented cognitive style (Nemiah, Freyberger, & Sifneos, 1976; Taylor, 1994; Taylor, Bagby & Parker, 1991). Collectively, these traits are thought to reflect a deficit in the cognitive processing and regulation of emotional states (Taylor et al., 1991, 1997).

The alexithymia construct provides potential explanations for the relationship between individual differences in emotion processing and regulation, on the one hand, and susceptibility to or resilience against certain somatic and mental disorders, on the other hand. For instance, the limited subjective awareness and cognitive processing of emotion associated with alexithymia are thought to lead to a concentration on and amplification of the somatic sensations that accompany emotional arousal. Misinterpretation of these sensations could result in functional somatic complaints and lead to hypochondriasis or somatization disorder (Taylor et al., 1997). Alternatively, individuals might attempt to diffuse unpleasant bodily tension through physical actions such as compulsive exercising, binge-eating, and substance abuse (Lane & Schwartz, 1987; Taylor & Bagby, 1988). In addition, failure to regulate distressing emotions through cognitive processes might result in prolonged states of sympathetic nervous system arousal (Luminet, Rimé, Bagby, & Taylor, in press), which could contribute to the development of certain types of somatic illness such as functional gastrointestinal disorders (Porcelli, Taylor, Bagby & De Carne, 1999) and essential hypertension (Jula, Salminen, & Saarijärvi, 1999; Todarello, Taylor, Parker & Fanelli, 1995).

Support for the validity of the alexithymia construct derives primarily from correlational studies (see e.g., Taylor, Bagby, Ryan & Parker, 1990; Taylor et al., 1997). There are comparatively fewer studies examining its validity using experimental designs. It is thus essential to produce empirical evidence that supports predictions as to the way in which people who score high on this construct should differ from those who score low (e.g., Eysenck & Eysenck, 1985). Recently, information processing theories of alexithymia have been proposed, in which alexithymia is viewed as a deficit in the delivery and use of emotional knowledge (Frawley & Smith, 2001).

If alexithymia reflects a deficit in the capacity to process and regulate emotions through cognitive processes, high alexithymia scorers should evidence impairment in performing cognitive-affective tasks as compared to low alexithymia scorers. This assumption was supported by various findings. To illustrate, Paez, Velasco, and Gonzalez (1999) showed that high alexithymia scores were negatively related to both the proportion of self-references in the total number of words used when writing about a traumatic event and the introspective content of the essays. High alexithymia scorers also reported less enjoyment and less involvement in relaxation exercises (Friedlander, Lumley, Farchione, and Doyal, 1997). Finally, Vanman, Dawson, and Brennan (1998) showed that high alexithymia scorers assessed negative slides as less unpleasant than did low alexithymia scorers. Thus, alexithymia seems to be related to a deficit in the verbal processing of emotional information.

Other studies have suggested that deficits observed in the processing of emotional information are not limited to verbal stimuli but extend to behavioral/expressive responses. High alexithymia scorers display significantly less intense facial reactions (McDonald & Prkachin, 1990), show less nonverbal emotional expressivity (Troisi et al., 1996), and are less competent at accurately recognizing posed facial expressions of emotion than the low alexithymia scorers (Jessimer and Markham, 1997; Mann, Wise, Trinidad, & Kohanski, 1994; Parker, Taylor, & Bagby, 1993). Higher alexithymia scorers are also less adept at matching verbal or nonverbal emotional stimuli with verbal or nonverbal emotion responses (Lane et al., 1996). These results suggest that alexithymia involves a general impairment (verbal and nonverbal) in the capacity of encoding and transforming emotional information.

Previous studies examining the impact of alexithymia on emotional information processing did not closely examine the type of processes involved, such as the distinction between deficits at a conscious level and at an automatic level. If high alexithymia scorers evidence deficits at the conscious level of emotion processing, as some studies reviewed above suggest, it is still possible that the way they process emotion at an automatic level is not hampered. From this perspective, one powerful technique used in experimental psychology for assessing the early allocation of attention to affective information is the affective priming paradigm (e.g., Bargh, Chaiken, Govender, & Pratto, 1992; Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Hermans, de Houwer, & Eelen, 1994, 2001). This paradigm is based on the well supported assumption that affect-evoking objects attract attention, and thus that word meaning is processed at an automatic level and cannot be completely ignored (Forgas, 1994; Pratto & John, 1991; Roskos-Ewoldsen & Fazio, 1992). The basic principle of the affective priming task is to examine whether the brief presentation of a first evaluative stimulus, the prime, affects the processing of a subsequent stimulus, the target, without any intention on the part of the respondent. Participants are typically asked to give an evaluative judgment (good vs. bad) related to the target. When the valence of the prime is identical to the valence of the target (positive-positive or negative-negative) and the time between the display of the prime and of the target is brief (SOA [1] < 300 ms) facilitation or congruency effects are observed (faster RTs as compared to control trials with neutral primes; for a review, see Klauer, 1998). When the valence of the prime differs from the valence of the target (positive-negative or negative-positive) inhibition or incongruency effects are observed (slower RTs as compared to control trials with neutral primes). Various hypotheses have been offered to account for these effects. The most relevant ones are path facilitation/interference (Wentura, 1999), automatic vigilance (Pratto & John, 1991), spreading of activation (Bower, 1991; Neely, 1991), postlexical (de Groot, 1984; Klauer & Stern, 1992; Neely & Keefe, 1989; Ratcliff & McKoon, 1981), and affective-motivational (Hermans, de Houwer, & Eelen, 1996). These various accounts differ in their emphasis on automatic vs. strategic decisions, on cognitive vs. emotional primacy, and on the possible moderation by valence effects.

A few studies have started to examine automatic affective-priming effects as a function of alexithymia (Suslow, 1998; Suslow, Junghanns, Donges, & Arolt, 2001). In one study, Suslow (1998) examined facilitation effects based on a pronunciation task and on an evaluation task. In the latter, people had to assess the target as good or bad as quickly as possible. Only the evaluation task evidenced significant relationships with alexithymia. Higher alexithymia scores were positively associated with facilitation effects when congruent positive prime-target pairs were presented, but not when congruent negative prime-target pairs were presented.

Recently, Suslow et al. (2001) examined both facilitation <u>and</u> inhibition effects with verbal and nonverbal stimuli. For verbal stimuli, primes were positive, negative and neutral nouns and targets were positive and negative adjectives. For nonverbal stimuli, primes were sad, happy, and neutral faces and targets were sad and happy faces. The dependent variable was RTs to an evaluative task (targets were assessed as good or bad). Results showed that for verbal information, alexithymia is positively related to facilitation when congruent negative primes and targets are presented. In these two studies, authors found that alexithymia was positively associated with facilitatory influence of the primes. However, results were contradictory as regards the valence of the material. While a moderating impact of alexithymia on facilitation was only found with positive material in the first study (Suslow, 1998), the effect was only found with negative material in the latter study (Suslow et al., 2001). Importantly, the authors did not discuss these conflicting results. They only interpreted them as evidence that, for high alexithymia scorers, valenced primes are treated as response-relevant cues which do not attract much attention. Without further replications, these results need to be interpreted very cautiously. Finally, Suslow and Junghanns (2002) used neutral and emotional contextual situations in a lexicon decision task (word – non-word) in which targets were emotional and neutral words. They found that, for low alexithymia scorers, the presentation of an emotional situation as a prime facilitates the lexical decision when a related emotion word is presented as compared to the presentation of an unrelated prime. For high alexithymia scorers, a negative situation priming effect was observed: when an emotion target was preceded by an unrelated prime, lexical decision tended to be faster than when it was preceded by a prime specific to that emotion. These results suggest that high alexithymia scorers are impaired in linking emotion-eliciting situations and emotional concepts.

Although studies by Suslow et al. provided preliminary evidence on the role of alexithymia in the processing of affective information, limitations may restrict the validity of this work. First, sample sizes were usually low (N = 32 in Suslow, 1998; N = 31 in Suslow et al., 2002), which questions the validity of the results. Second, each design was tested in a single study. The effects were thus not replicated. Third, alternative trait variables to alexithymia and mood state were not included in the design (Suslow, 1998; Suslow et al., 2002). In Suslow et al. (2000), measures of trait anxiety and of mood states were considered but they were not included as covariates in the analyses. The results are thus open to alternative explanations as alexithymia is moderately, but significantly, associated with higher neuroticism, lower extraversion, and lower openness to experience(Bagby, Taylor and Parker, 1994b; Luminet, Bagby, Wagner, Taylor, & Parker, 1999; Wise & Mann, 1994; Wise, Mann and Shay, 1992). Fourth, in some cases no information was provided on the way the words were selected (Suslow, 1998), and in others the number of criteria for selection were limited (Suslow et al., 2001). Results can thus be explained by other aspects than the valence of words (e.g., ambiguity, abstraction, imageability, familiarity, …). Fifth, and most importantly to our present concern, primes were presented for 200 Ms with SOA of 300 Ms, which makes it impossible to guarantee that automatic processing was involved. Indeed, due to individual differences in the speed of processing, it is likely that some participants could use conscious strategies when responding to the target. The studies reported in the present paper were designed to overcome these limitations.

Overview

We predicted that alexithymia would disrupt the automatic processing of affective information. Specifically, we predicted that affective priming effects would become smaller as a function of participants' alexithymia score, reflecting an overall deficit in the automatic processing of affective information. In the first two studies, verbal (positive and negative) and nonverbal (angry vs. happy in Study 1 - and angry vs. sad vs. happy in Study 2) words and face primes were presented followed by positive and negative nouns. RTs for affective decisions on affectively congruent and incongruent pairings were considered. Study 3 tested whether the moderating impact of alexithymia can be explained by impairments in switching from facial information into verbal information and the other way round (i.e., a transcoding deficit) rather than by impairments in the processing of emotional information.

Study 1

Method

Design

This experiment was designed to allow the observation of congruency and incongruency effects as a function of alexithymia scores. We used a 2 (type of prime : words vs. faces) x 3 (valence of prime : neutral vs. positive vs. negative) x 2 (valence of target : positive vs. negative) full within-participants design. Alexithymia was used as a continuous variable.

Participants

Sixty-four undergraduate students (39 women) at the graduate school in economics at the University of Louvain at Louvain-la-Neuve served as participants in fulfilment of a course requirement. The mean age of the participants was 20.46 years (*SD* = 2.21). The study was introduced as social psychology research without mention of emotional implications.

Measures

Toronto-Alexithymia Scale (TAS-20). The Toronto-Alexithymia Scale 20 item (TAS-20) is the most widely used measure of the alexithymia construct (Bagby & al., 1994a, 1994b). Concurrent, predictive, convergent and discriminant validity, reliability and stability have been demonstrated (for a review, see Taylor, Bagby, & Luminet, 2000). It consists of self-report statements of 20 items on 5-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree), with five items negatively keyed. The TAS-20, which has a 3-factor structure, is divided into 3 subscales : 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 French version of the scale used for the present study has been validated by Loas, Otmani, Verrier, Fremaux, and Marchand (1996) and by Loas, Parker, Otmani, Verrier, and Fremaux (1997). Possible scores range from 20 to 100.

Although participants from this study were non-clinical students, the distribution of alexithymia scores was broad as shown by the range of scores and the values for skewness (see Table 1). Based on Taylor et al.(1997), people are considered as non-alexithymic if their score is below or equal to 51. In the present study, 57.8 % of the sample can be classified as such. A score from 52 to 60 represents moderate alexithymia levels. In the present study, 29.7% of the sample was in that category. Finally, we had 12.5% of the sample above or equal to the clinical threshold of 61. These results show that alexithymia scores were distributed in a similar way to other samples using normative groups. These results are highly comparable to the total number of people (N = 1897) who have completed the TAS-20 in our laboratory in the last five years (Luminet & Vermeulen, 2004). In this larger sample, 61.4 % of the sample have a score below or equal to 51, 28.1 % have a score from 52 to 60 and finally, 10.5 % of the sample above or equal to the clinical threshold of 61.

Negative Affectivity Schedule (NA). The Negative Affectivity Schedule (NA) is a 10-item scale which assesses negative mood states (Watson, Clark, & Tellegen, 1988). It consists of negative (e.g., guilty, irritable) emotional states rated on 5-point scales ranging from 1 (not at all) to 5 (extremely). The NA Schedule is the most widely used scale for the assessment of current negative mood states. Possible scores range from 10 to 50.

Materials and apparatus

Stimuli. Twelve positive and 12 negative French nouns selected from Messina, Morais and Cantraine (1989) and from Leleu (1987) were used as target stimuli (e.g., hope, friend, cancer, bereavement). Positive and negative nouns were not different in length (i.e. number of letters), $F(1, 23) < 1$, ns (positive: $M = 6.25$, $SD = 1.48$); negative: $M = 6.33$, $SD = 1.15$), and for emotionality (from 1 “not linked to emotion” to 7 “strongly linked to emotion”), $F(1, 23) < 1$, ns (positive: M = 6.02, $SD = 0.36$; negative: $M = 5.75$, $SD = 0.44$). Positive and negative nouns were strongly different for valence (from -3 “strongly unpleasant” to +3 “strongly pleasant”), $F(1, 23) = 1955.18$, $p < 0.001$ (positive: $M = 2.31$, $SD = 0.34$; negative: $M = -2.64$, $SD = 0.19$). We used both verbal and schematic faces as primes. Verbal primes were 12 emotional adjectives (six positive and six negative – e.g., joyful, delighted; frightened, furious), and 6 non-word six-letter strings (i.e., xxxxxx) which served as baseline. Positive and negative adjectives were already pretested in a previous study on 17 independent judges (age : $M = 23.35$, $SD = 1.23$). No differences were found for length, $F(1, 11) < 1$, ns (positive: $M = 7.16$, $SD = 1.83$; negative: $M = 6.83$, $SD = 0.98$), nor for emotionality (from 0 “not linked to emotion” to 6 “strongly linked to emotion”), $F(1, 11) < 1$, ns (positive: $M = 4.93$, $SD = 0.52$; negative: $M = 4.80$, $SD = 0.40$), nor for ambiguity, abstraction, imageability, and familiarity, ps > 0.10 (for all, from 0 “not at all” to 6 “extremely”). Positive and negative adjectives were strongly different for valence (from -3 “strongly negative” to +3 “strongly positive”), $F(1, 11) = 157.63$, $p < 0.001$ (positive: $M = 2.17$, $SD = 0.31$; negative: $M = -1.91$, $SD = 0.26$). Schematic faces (see Figure 1) were built from those examined by Lundqvist, Esteves and Öhman (1999) who controlled for the effect of different facial features (shape of the eyebrows, eyes, mouth). The most negative face of their study was selected for the present one. The positive face was a modified version of the most positive face presented by Lundqvist et al. (1999). The size of the smile was enlarged to make it deeper. The neutral face was designed for this study by using Lundqvist et al. 's facial features (shape of the eyebrows, eyes, mouth) in order to keep visual complexity constant. The mouth and the eyebrows were flat and the eyes were oval. A pre-test carried out on the positive face with 10 judges (age : *M* = 22.9, *SD* = 2.6) showed the face we designed was the most positive one even if compared with the Lundqvist et al. (1999) smiling face.

Stimuli were presented by PsyScope 1.2.5 for PPC on a Power MacIntosh G3, 233 MHz / 96 Mb SDRAM computer with a 15 inch Trinitron colour monitor. Response latencies were recorded by pressing one of two response keys, respectively F for negative and J for positive, on an Azerty Keyboard.

Procedure

The participants were tested in collective sessions of up to 16 students in a computer room. They were seated in front of the monitor and were invited to read carefully the instructions that appeared on the screen. They were asked to evaluate each of the targets as positive or negative as quickly and accurately as possible. All participants first completed 12 practice trials in order to become familiar with the procedure. Then, they were exposed to the experimental trials, each including sequentially a fixation point, a prime lasting for 100 ms, and a target word presented for 500 ms. Inter-trial interval was 1500 ms. The stimulus onset asynchrony (SOA) was 100 ms, as recommended by Klauer, Robnagel and Musch (1999). The targets were divided into three blocks of four positive and four negative nouns. Each target was randomly preceded by the six Prime Types (words: positive, negative, neutral; faces: positive, negative, neutral). The positive, negative and neutral prime faces were always the same, but the prime words were different in each block (two negative and two positive in each block). The three experimental blocks contained 48 trials each, resulting in the completion of 144 experimental trials in total. The three randomly presented blocks were separated by a rest period of 30 seconds. The experiment lasted about 12 minutes in total. Once the task was completed, participants were asked to fill out the TAS-20 and the Negative Affectivity Schedule (NA).

Results

Overall congruency and incongruency effects

At a general level, participants responded faster when the valence of the prime and the valence of the target were congruent (*M* = 678.16, *SD* = 94.14) than when the valence of the prime and the valence of the target were incongruent (*M* = 706.31, *SD* = 99.38), $t(63) = 4.50$, $p < .001$. This effect was moderated by the type of prime (verbal or non-verbal) and by the valence. For congruent pairs, targets were responded to faster when the primes were non-verbal (*M* = 669.61, *SD* = 97.74) than when the primes were verbal (*M* = 686.71, *SD* = 95.50), $t(63) = 3.14$, $p = .003$, and targets were responded to faster when the pairs were positive (*M* = 668.73, *SD* = 94.94), than when the pairs were negative (*M* = 687.59, *SD* = 97.98), $t(63) = 3.58$, $p < .001$. For incongruent pairs, targets were responded to faster when the primes were non-verbal (*M* = 688.84, *SD* = 101.78) than when the primes were verbal (*M* = 723.55, *SD* = 105.08), $t(63) = 4.74$, $p < .001$, but no effect of the valence was observed for incongruent pairs (see Table 2).

Moderating impact of Alexithymia on priming effects

Four indices were computed to examine the influence of the Prime Types (positive words, negative words, happy face, and angry face) on participants' evaluative decisions.

1. Influence of the positive word primes = [mean RTs for positive words preceded by positive words as compared to baseline primes (i.e., facilitation) – mean RTs for negative words preceded by positive as compared to baseline primes (i.e., inhibition)].

2. Influence of the negative word primes = [mean RTs for negative words preceded by negative words as compared to baseline primes (i.e., facilitation) – mean RTs for positive words preceded by negative as compared to baseline primes (i.e., inhibition)].

3. Influence of the happy face prime = [mean RTs for positive wor ds preceded by a happy face as compared to a neutral face (i.e., facilitation) – mean RTs for negative words preceded by a happy as compared to a neutral face (i.e., inhibition)].

4. Influence of the angry face prime = [mean RTs for negative words preceded by an angry face as compared to a neutral face (i.e., facilitation) – mean RTs for positive words preceded by an angry as compared to a neutral face (i.e., inhibition)].

These indexes were regressed separately on participants' TAS score, with participants' NA score entered in the model as covariate. The regression involving the angry face prime came out significant, with the affective priming effect of the angry face becoming smaller as participants' TAS score increased, *ß* = -.267, t(60) = -2.169, *p* = .03, two-tailed. The impact of the other prime types (happy face, positive prime words, negative prime words) did not depend on participants' TAS score when controlling for NA.

Discussion

Systematic facilitation and inhibition effects observed as a result of the congruence or incongruence between the valence of the prime and the target support previous findings observed in affective-priming tasks (Banse, 2001; Klauer, 1998; Suslow, 1998; Suslow et al., 2001). They also confirm the validity of the material designed for the present study. More importantly, the present results suggest that alexithymia may disrupt the automatic processing of affective information. Indeed, the effect of the angry face decreased as a function of participants' alexithymia score. The fact that alexithymia specifically moderates the automatic influence of angry face primes on evaluative judgments is difficult to interpret as alexithymia was found to be related to impaired recognition for all basic facial expressions (Lane et al., 2000). However, up to now, no study has addressed “automatic” processing of facial information in alexithymia in which no explicit evaluation of facial expression is required. Actually, it is still possible that alexithymia mainly impairs automatic processing of negative facial information that is known to be detected more readily among other faces (Hansen & Hansen, 1988 ; Öhman et al., 2001). Being slower at responding to a threatening social signal could be highly deleterious for adaptation as threatening signals (i.e., specifically angry, not “negative”) should require urgent reactions. Another limitation of the first study is that the effects could be explained by other alternative variables such as depression or anxiety that are known to be related to alexithymia (Eizaguirre, de Cabezon, de Alda, Olariaga, & Juaniz, 2004 ; Marchesi, Brusamonti, & Maggini, 2000). The second study was conducted with the following aims: 1) to test the replicability of the moderating impact of alexithymia on the processing of angry faces; 2) to extend the investigation to the processing of other negative states; 3) to control for additional alternative explanations than negative mood.

Study 2

Study 2 was conducted in order to examine whether the effects observed in Study 1 could be replicated and generalized given an additional control for other personality traits generally associated with the alexithymia construct. Beside general mood effects assessed by NA, Study 2 also controlled for trait-anxiety (Spielberger, Gorsuch, Luchene, Vagg, & Jacobs, 1983) and depression (Zung, 1965). If Study 2 can replicate the findings obtained in Study 1, while partialling out NA, depression and trait-anxiety, it would represent strong evidence that the disruptive impact of alexithymia on the automatic processing of affective information is due to a unique contribution of this latter construct, rather than to other personality traits or transient mood states.

In addition, the present study sought to examine whether the effects obtained in Study 1 were specifically due to the presentation of an angry face prime, or whether they would generalize to other negative face patterns. Accordingly, we included a sad face prime in this second study. Finally, the letter-strings used in Study 1 were replaced by neutral words in order to provide a better baseline in estimating affective priming effects (rows of 'XXXXXX' primes are typically associated with faster Rts than real words on answers to subsequent targets).

Method

Design

We relied on a 2 (type of prime : words vs faces) x 4 (nature of prime : neutral vs joy vs angry vs sad) x 2 (valence of target : positive vs negative) full within-participants design. Alexithymia was used as a continuous variable.

Participants

Sixty undergraduate psychology students at the University of Louvain at Louvain-la-Neuve served as participants in fulfilment of a course requirement. Two participants were outliers and were excluded from analysis on the basis of their mean reaction time (greater than 2 SD from the group mean). The mean age of the 58 remaining participants (49 women) was 19.45 years (*SD* = 2.25). The study was introduced as psychology research without mention of emotional implications.

Measures

As in the first experiment, we measured the level of alexithymia with the Toronto Alexithymia scale 20-item (TAS-20) and negative affectivity with the NA Schedule (for a description, see measures section of the first experiment). In regard to the distribution of alexithymia scores, only 56.9 % of the sample obtained a score $\leq$ 51 to be considered non-alexithymics. 31.0 % had a score between 52 and 60 and are thus considered to be moderately alexithymic. Finally, 12.1 % of the participants of the sample scored $\geq$ 61, with the maximum score at 78. Overall, the distribution of alexithymia scores in study 2 (see Table 1) was very close to the one observed for Study 1.

The following additional personality measures were also used:

Spielberger's State-Trait Anxiety Index (STAI). The state form of the STAI is a self-rating measure of Anxiety (Spielberger et al., 1983). Participants indicated their degree of approval on 20 items (e.g., "I am satisfied ", "I have some thoughts that disturb me") on a 4-point Likert scale ranging from 1 "No" to 4 "Yes". Possible scores range from 20 to 80.

Zung. The Zung questionnaire is a self-rating measure of the physiological and psychological symptoms of depression (Zung, 1965). For each of the 20 items, participants were asked to put a cross in the box which corresponded to their choice, from 1 "rarely" to 4 "nearly always". Possible scores range from 20 to 80.

Materials and apparatus

Stimuli. Some slight changes as compared to the first study were implemented. Three positive and three negative words were added to the set of target stimuli in order to vary the presentations of the experiment and to match as well as possible the emotion of the targets with the emotion of the primes. New positive words were strongly linked to happiness (e.g., joy, smile) and new negative words were linked to sadness (e.g., sorrow, depression). This new material was selected from Messina et al. (1989) and from Leleu (1987) and was pretested in a pilot study (for details see footnote 2). Threatening words were the same as those used in Study 1 (e.g., crime, cancer, pain). Finally, a sad face selected from Lundqvist et al. (1999) (see Figure 1) was added to the three schematic faces used in the first experiment

Stimuli were presented by PsyScope 1.2.5 for PPC on a Power MacIntosh G3, 233 MHz / 96 Mb SDRAM computer with a 15 inch Trinitron colour monitor. Response latencies were recorded by pressing one of the two response keys, respectively F for negative and J for positive, on an Azerty Keyboard.

Procedure

All participants were exposed to 210 trials, which sequentially consisted of a fixation point, a prime lasting for 100 msec, and a target presented for 500 msec. Inter-trials intervals were 1500 msec. We used the same stimulus onset asynchrony (SOA) as in the first Study (100 Ms). The targets were divided into three blocks of five positive and five negative nouns each.

Each target was randomly preceded by seven kinds of prime (Words: positive, negative, neutral; Faces: positive, angry, sad, neutral). The schematic faces were always the same but positive and negative word primes were different in each block (two negative and two positive in each block). Thus, each block contained 70 experimental trials. The blocks were randomly presented and separated by a rest period of 30 seconds.

Participants were run in collective sessions in a computer room. They were seated in front of a monitor and were invited to read attentively the instructions that appeared on the screen. They were asked to evaluate each of the targets as positive or negative as quickly and accurately as possible. Participants first completed 12 training trials in order to become familiar with the task. Then, they proceeded to the experimental trials. The experiment lasted about 20 minutes in total. Once the task was completed, participants filled out the full set of questionnaires (see above).

Results

Overall congruency and incongruency effects

At a general level, participants responded faster when the valence of the prime and the valence of the target were congruent (*M* = 631.00, *SD* = 82.32) than when these were incongruent (*M* = 642.20, *SD* = 77.76), t (57) = 3.12, p = .003. This effect was moderated by the type of prime (verbal or non-verbal) and by the valence. For the congruent pairs, targets were responded to faster when the primes were non-verbal (*M* = 623.22, *SD* = 78.19) than when the primes were verbal (*M* = 641.40, *SD* = 88.43), t (57) = 4.54, p < .001, and targets were responded to faster when the pairs were positive (*M* = 610.05, *SD* = 92.25), than when the pairs were negative (*M* = 643.53, *SD* = 80.25), t (56) = 6.24, p < .001. For the incongruent pairs, targets were responded to faster when the primes were non-verbal (*M* = 632.75, *SD* = 72.63) than when the primes were verbal (*M* = 651.20, *SD* = 85.92), t (55) = 3.51, $p < .001$, and targets were responded to faster when the targets were positive (*M* = 630.74, *SD* = 73.83), than when the targets were negative (*M* = 659.03, *SD* = 80.69), t (55) = 5.59, $p < .001$

Interference effects

Five indexes were computed to examine the influence of the Prime Types (positive words, negative words, happy face, angry face, and sad face) on participants' evaluative decisions. The first 4 indexes were computed as in Study 1. The fifth index, was computed as follows:

5. Influence of the sad face prime = [mean RTs for negative words preceded by a sad face as compared to a neutral face (i.e., facilitation) – mean RTs for positive words preceded by a sad as compared to neutral face (i.e., inhibition)].

These indexes were regressed separately on participants' TAS score, with participants' NA, trait-anxiety and depression scores entered in the model as covariates. The regression involving the angry face prime again came out significant, with affective priming effects due to the angry face becoming smaller as participants' TAS score increased ß = -.416, t(53) = -2.939, $p < .005$. The impact of the other Facial Primes (happy face, sad face) did not depend on participants' TAS score when controlling for NA, trait-anxiety, and depression, ß = .231, t(53) = 1.587, $p > .10$ and *ß* = -.238, t(53) = -1.593, $p > .10$, respectively for happy and sad face primes.

Discussion

As in Study 1, systematic facilitation and inhibition effects were observed as a result of the congruence or incongruence between the valence of the prime and the target. These results thus support the validity of the materials we used. This study also replicates and extends our findings regarding the moderating impact of alexithymia. Firstly, Study 2 confirms the link between alexithymia and the automatic influence of angry face prime on either positive and negative evaluative responses. Secondly, Study 2 extends the conclusions of Study 1 in showing that the results could not be attributed to the negative valence of the primes but rather must be attributed to the specificity of angry faces or to the combination of the negative valence and the high level of arousal as moderating effects that were found with the angry face prime but not with the sad face prime. Taken together, these results suggest that alexithymia disrupts the automatic processing of affective information but specifically for angry faces or for, more generally, high arousal negative information. Finally, results from Study 2 indicate that the moderating impact of alexithymia cannot be explained by other trait measures such as depression or anxiety.

Whereas Study 2 provides further support to the view that alexithymia impairs the automatic processing of affective information, a careful reader may argue that the present effects were obtained because of *transcoding* limitations among alexithymic individuals. According to this view, high alexithymia scorers may have been impaired in their processing of angry face prime/verbal stimuli pairings because of a difficulty to matching nonverbal with verbal information (Lane et al., 1996). We sought to provide a formal test for this transcoding account. The reasoning was straightforward: if the moderating effects of alexithymia obtained in Study 1 and 2 were due to transcoding limitations, then these effects should be replicated on verbal primes/angry face stimuli pairings. Study 3 was designed to test for such a possibility. In this study, participants were either exposed to a verbal prime followed by a nonverbal target or to a nonverbal prime followed by a verbal target. Additionally, this study provides a new opportunity for testing how replicable the results obtained in Study 1 and 2 are.

Study 3

Method

Design

We relied on a 2 (type of pairs : word-face vs face-word) x 3 (valence of prime : neutral vs positive vs negative) x 2 (valence of target : positive vs negative) full within-participants design. Alexithymia was used as a continuous variable.

Participants

Sixty-five undergraduate psychology students at the University of Louvain at Louvain-la-Neuve served as participants in fulfilment of a course requirement. Five participants were outliers and were excluded from analysis on the base of their mean reaction time (greater than 2 SD) or on the basis of their mean error rates (greater than .25). The mean age of the 60 remaining participants (45 women) was 20.60 years (*SD* = 4.40). The study was introduced as cognitive psychology research without mentioning the emotional implications.

Measures

As in the first two studies, we measured level of alexithymia with the Toronto Alexithymia scale 20-item (TAS-20), negative affectivity with the NA Schedule, anxiety with STAI and Depression with Zung (for a description, see measures sections of the two former studies). Participants in this study presented a good distribution of TAS-20 score (see Table 1).

In this third study, 68.3 % of the sample obtain a score $\leq$ 51 and could be considered as non alexithymics. 26.7 % had a score between 52 and 60 and are thus considered as moderately alexithymic. Finally, 5.0 % of the participants of the sample have a score $\geq$ 61 with the maximum score at 66.

Materials and apparatus

For the facial-verbal associations, we used the same design and material as in Study 2 except that we only used 24 verbal targets, which were identical to the ones used in Study 1. For the verbal-facial associations, word primes were those used in Study 1 for the verbal-verbal associations. Twenty-four target pictures were selected from Beaupré, Cheung, & Hess (2000), In which half were women and half were men. Twelve pictures depicted happy expressions and the other twelve were negative, depicting sad, angry or disgusted expressions.

Stimuli were presented by E-Prime 1.1.4.1 on PCs with Processor IntelPentium 2.3 GHz / 256 Mb SDRAM computer with a 17 inche colour monitor. Response latencies were recorded by pressing one of the two response keys, respectively F for negative and J for positive, on an Azerty Keyboard.

Procedure

All participants were exposed to 72 verbal-facial pairs and 96 facial-verbal pairs leading to a total number of 168 trials**.** Half of the participants started with verbal-facial associations, while the other half started with facial-verbal associations. Each trial sequentially consisted of a fixation point, a prime lasting for 100 msec, and a target presented for 500 msec. Intertrial intervals were 1500 msec. We used the same stimulus onset asynchrony (SOA) as in the previous two studies (100 Ms). In the verbal-facial pairs, each of the 24 photographs was randomly preceded by 3 kinds of prime (i.e., Positive, Negative and Neutral words). In the facial-verbal pairs, each of the 24 words was randomly preceded by four kinds of prime (i.e., Happy, Sad, Angry and Neutral schematic faces). Participants were run in a computer room in group sessions of up to eight people in each session. They were seated in front of a monitor and were invited to read carefully the instructions that were presented on the screen. They were asked to evaluate each of the targets as positive or negative as quickly and accurately as possible. Participants first completed 12 training trials in order to become familiar with the task. Then, they proceeded with the experimental trials. The experiment lasted about 15 minutes in total. Once the task was completed, participants filled out the full set of questionnaires: TAS-20, PANAS, Zung and STAI (see above).

Results

Overall congruency and incongruency effects

At a general level, participants responded faster when the valence of the prime and the valence of the target were congruent (M = 664.30, SD = 96.47) than when they were incongruent (M = 683.87, SD = 99.21), t (59) = 4.04, p < .001. This effect was not moderated by the type of pairs (non-verbal - verbal or verbal – non-verbal) but by valence. For congruent pairs, targets were responded to equally fast whether the primes were non-verbal (M = 674.95, SD = 109.46) or verbal (M = 648.32, SD = 123.00), t (59) = 1.61, p > .10, but targets were responded to faster when the pairs were positive (M = 640.35, SD = 94.85), than when they were negative (M = 680.26, SD = 103.23), t (59) = 5.78, p < .001. For incongruent pairs, targets were responded to equally fast whether the primes were non-verbal (M = 680.66, SD = 107.00) or verbal (M = 688.68, SD = 103.23), t (59) < 1, ns, but targets were responded to faster when the pairs were positive (M = 673.71, SD = 103.19), than when they were negative (M = 699.10, SD = 103.99), t (59) = 3.26, p = .002 (see Table 2).

Interference effects

Five indexes were computed to examine the influence of the Prime Types (positive words, negative words, happy face, angry face, and sad face) on participants' evaluative decisions. Indexes were computed the same way as in Study 1 and in Study 2 (for sad prime) except that in Study 3, the impact of positive and negative word primes were additionally tested on target pictures.

These indexes were regressed separately on participants' TAS score, with participants' NA, trait-anxiety and depression scores entered in the model as covariates. The regression involving the angry face prime again came out significant, with affective priming effects due to the angry face becoming smaller as participants' TAS score increased $ß$ = -.262, $t(56)$ = -1.881, p = .06.

Moreover, the impact of the other Facial Primes (happy face, sad face) and the impact of prime words on Facial Target did not depend on participants' TAS score.

Cross study follow-up analysis

Although results from the three studies only showed moderating impact of alexithymia for nonverbal angry primes, it is possible that the non-significant results obtained for the other categories of primes were due to a lack of statistical power. In order to clarify the issue of specificity in alexithymia scores on the processing of anger primes, we decided to consider the three studies together[3]. We were able to merge the samples of the different studies as the procedures and material used in these studies were identical.

After we merged the different samples, no moderation of alexithymia on the impact of the happy face (n = 182), $ß = .098$, $t(179) = 1.29$, n.s. was found and alexithymia only tended to moderate the impact the sad face prime (n = 118), $ß = -1.85$, $t(115) = -1.91$, $p = .06$. However, for the angry face, the effect was still highly significant, $ß = -.263$, $p < .001$. Because these general effects involved a facilitation and an inhibition influence of the prime face (see the above computations in interference effects), we also separately regressed each of these two components on the same 2 factors (TAS and NA scores). Regarding the moderating influence of alexithymia for the angry face prime, we found that the relation was highly significant in facilitation, $ß = -.219$, $p = .004$ and was significant in inhibition, $ß = .176$, $p = .02$. Moreover, at these specific levels (inhibition and facilitation) the influence of alexithymia level on the other face prime (sad and happy) were far from significance, all *p*'s > .10. We also conducted additional analyses in order to compare the moderating effects of alexithymia on anger faces to the moderating effects of alexithymia on happy and sad faces. We computed scores based on the differences between the general effect of the angry face and the general effect of happy and sad faces. At the general level, we found that alexithymia moderates more the influence of the angry face compared to the happy face ($p = .002$) and did not moderate more the influence of the angry face compared to the sad face ($p = .13$). At specific levels, for inhibition, alexithymia moderates more the influence of the angry compared to happy face ($p < .02$) but not compared to the sad face ($p > .10$). However, for facilitation, alexithymia moderates more the influence of the angry prime compared to the two others ($p = .001$).

Discussion

Globally, as was the case in the two former studies, systematic facilitation and inhibition effects were observed as a result of the congruence or incongruence between the valence of the prime and the target. This was true for facial – verbal pairs and for verbal – facial pairs. More importantly, the results of Study 3 again replicated the findings obtained in Studies 1 and 2 showing that alexithymia moderated the impact of angry face prime on evaluative judgments for affective targets. The present results would also exclude the assumption that the moderating impact of alexithymia can be explained by a deficit in the transcoding between verbal and nonverbal information. This is because no moderation effects were found when verbal primes were followed by nonverbal targets. Moreover, the cross study analyses underline that the specificity of the moderating impact of alexithymia on angry primes seems to be quite robust. As merging the different studies allowed for large sample size, the absence of moderating impact of alexithymia on happy and sad primes is very unlikely to be due to a lack of statistical power. It is also important to remember that the results supporting the specificity hypothesis were obtained after controlling for alternative variables and in samples in which alexithymia scores were adequately distributed.

General Discussion

In three studies, we examined the moderating impact of alexithymia in affective priming. The comparisons were made across different types of associations (i.e., verbal – verbal, facial – verbal, and verbal – facial). Despite these variations of pairs across the three studies, we unconditionally found consistent and robust facilitation and inhibition effects depending on the congruence or the incongruence between the valence of the prime and the subsequent evaluation of the valence of the affective target. We also perfectly replicated the findings showing that alexithymia moderated the impact of angry face prime on evaluative judgments for affective targets. However, alexithymia did not moderate the impact of the happy schematic face, nor of the sad one on evaluative judgments.

Overall, these results support the view that high alexithymia scorers process less emotional information at an automatic level. Importantly, these results cannot be explained by current mood state, since we controlled for participants' level of negative affectivity. They cannot be explained either by alternative dispositional tendencies usually associated with alexithymia, such as trait-anxiety and depression. The present studies thus give strong support to the view that the alexithymia construct exercises specific effects on the automatic processing of emotional information. Study 3 also showed that the effect could not be attributable to a transcoding deficit. It has been shown that low and high alexithymia scorers differ in their ability to explicitly match nonverbal and verbal emotional information with verbal and nonverbal emotional responses (Lane et al., 1996). In the present studies, the effect observed with angry face prime could not be attributed to that kind of matching inabilities since no effect was found in the verbal prime– non verbal target associations.

The present results are in opposition with previous results that examined automatic affective processing in alexithymia (Suslow, 1998; Suslow et al., 2001). Although interesting, these previous studies did not allow for conclusions because there were some limitations that restricted their validity (see Introduction). Our studies bypass these limitations. We replicated the effects three times with larger sample sizes and the effect remains significant after controlling for alternative variables. Moreover, regarding the procedure, the material was strictly selected and we used a SOA that guaranteed that automatic processes were involved.

The present results also support the view that alexithymia is related to disorders of affect regulation (e.g., Taylor et al., 1997), in which individuals are impaired in connecting emotions to situational antecedents (e.g., Suslow et al., 2002). Being slower at responding to a threatening signal followed by threatening information can have deleterious effects, as threatening targets are indications that urgent reactions such as coping processes are required. High alexithymia scorers, as they take longer before reacting to congruent negative pairs, are thus exposed to higher risks when the target involves threatening characteristics. Emotions are important sources of information in decision making (Damasio, 1994; Bechara, Damasio, & Damasio, 2000). Using less emotional information can thus impair the reorganization of mental schemata required by the sudden trigger of threatening signals in the environment.

Types of Processes Involved in Alexithymia Deficits in Emotional Processing

There is a debate as to whether alexithymia is mainly a deficit in the receiving component (i.e., a defective functioning of the input system) or in the sending component (i.e., a defective output due to a loss of awareness in the sending of information) of information processing (Frawley & Smith, 2001). While our previous studies supported the sending component deficit (Luminet, Zech, Rimé, & Wagner, 2000; Luminet et al., 2004), the present data suggests an additional deficit in the receiving component. This deficit at the intake of information stage in high alexithymia scorers is characterized by a failure to respond in the usual way to elicitors of emotion. It has been related to low awareness of environmental cues and to incorrect appraisal of events as emotion signals (Lane et al., 1997; Taylor et al., 1997). These two aspects of the initial processing of information (cue detection and appraisal) would thus be disconnected. From this perspective, we showed that high alexithymia scorers have a different pattern of appraisals in relation to a negative emotional situation as compared to low scorers (Luminet et al., 2004): high scorers reported the emotional movie they were exposed to as less familiar and less important than low scorers.

A further disconnection in high alexithymia scorers could also be present during the detection phase. It seems relevant in this context to distinguish early detection from later processing. While the present results strongly suggest that high alexithymia scorers were slower and poorer at using facial threatening cues for making evaluative judgments, some studies suggest no impairment at very early stages of processing. Firstly, Vermeulen, Luminet and Corneille (2004a) recently showed that high alexithymia scorers do not differ from low scorers in their ability to detect an angry schematic face among either a happy crowd or a neutral crowd in a visual search paradigm (Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001). Secondly, Aftanas, Varlamov, Reva, and Pavlov (2003) used electroencephalographic measures (EEG) in a study in which high arousal affective pictures from the IAPS (Lang, Bradley and Cuthbert, 1999) were shown to the participants. The results indicated that low and high alexithymia scorers did not differ in their ability to detect the emotional salience of the stimulus 100 ms after the stimulus presentation. Taken together, these results support the view that alexithymia is not related to early attentional processes such as the detection of the salience of emotional stimuli, but rather to later processes such as automatic evaluative judgments.

The Specificity of Threatening Primes

The present results suggest that the moderating impact of alexithymia is specifically related to the automatic processing of threatening primes here represented by the use of angry faces. As presented in our “cross study analysis” section, the absence of moderating impact of alexithymia on happy and sad primes is very unlikely to be due to a lack of statistical power since we merged the different studies to enlarge sample size. Actually, we evidenced that the specificity of the moderating impact of alexithymia on angry primes is quite robust as it was observed through three studies even after controlling for alternative variables such as anxiety or depression. These results are highly coherent with recent data coming from neuroimaging and neurophysiological studies. For instance, Kano et al. (2003) showed a specific effect of alexithymia on brain reactivity to the implicit processing of an angry face as compared to neutral faces. High alexithymia scorers showed a deficit of anterior cingulate cortex (ACC) and insula reactivity to the automatic processing of angry faces when participants explicitly focus on the gender of these faces. Importantly, the ACC involvement in the Kano et al. study was not generalised to all facial displays of emotion but was specific to anger. This ACC involvement in alexithymia was also found in other brain imaging studies (Berthoz et al., 2002). Also, the study conducted by Aftanas et al. (2003) showed that between 0-200 ms after the high arousal affective picture onset, high alexithymia scorers demonstrated deficient synchronisation in the theta band over frontal sites which are assumed to rely mainly on ACC activation. Moreover, we evidenced using event-related potentials that alexithymia is related to a delayed preparation to process biologically prepotent events as measured by the orienting complex (N2/P3a) and that this deficit is stronger for angry faces (Vermeulen, Luminet, Cordovil de Sousa, and Campanella, 2004b). As ACC is known to be the main generator of these neurophysiological components, these findings support the hypothesis of a deficit in ACC functioning in alexithymia by indexing its delayed contribution around 300 ms. There is some empirical evidence that ACC reactivity is positively related to the intensity of anger (Blair et al.,1999). In other words, the more intensely the face depicted anger, the more ACC was activated. The link between ACC activity, alexithymia severity and angry processing thus seems highly relevant to explain the specific effects observed in our three affective priming studies. This specificity could be explained by the impairment of ACC functioning in high alexithymia scorers. ACC is considered as a key component of the somatic markers hypothesis (Damasio, 1999; Bechara & Naqvi, 2004). According to this model, ACC is required to assimilate the relationship between the organism and the emotional object and also, more generally, for the integration of information about the world with information about the body. Thus, ACC appears to be important in mapping bodily states onto feelings. Other recent studies emphasized the role of ACC in autonomic control and its influences on the regulation of bodily states (Critchley et al., 2001; 2003). These authors proposed that ACC could have a role in facilitating behavioural responses and in optimising bodily readiness prior to engaging in further behaviour (Critchley et al., 2003). Regarding our affective priming results, this optimisation of bodily readiness could in fact hold a central position in the decrease of the influence of the angry face prime. The angry face prime is highly salient and arousing as compared to the other faces used in our research design. Its processing thus requires quick self-regulating responses in order to cope with future behavioural demands. Once the angry face is detected, high alexithymia levels may be related to a lesser influence of its triggered bodily arousal states leading to smaller evaluative priming effects.

Finally, no moderating effects were observed when verbal primes were used. One possibility to explain this nonsignificant result is that the verbal primes used in the present studies involve less specific emotional states than the nonverbal ones. Verbal primes related to specific states (e.g., anger, sadness, joy) should thus be included in future studies to test for this explanation. Interestingly, the specific moderating impact of alexithymia on the angry face might also have some consequences for social interactions. Facial expressions provide meaningful information to the receiver in social contexts and also allow for important regulation strategies among the sender and the receiver (Keltner, Ekman, Gonzaga, & Beer, 2003). Additionally, facial expressions spontaneously evoke emotion responses in the receiver, as it was shown by studies on facial mimicry. For instance, Dimberg (1990) showed that angry expressions evoked facial expressions in the receiver and that these reactions can be present even when facial expressions were presented too quickly to allow conscious perception (Dimberg, Thunberg, & Elmehed, 2000). From this perspective, emotional expressions can “automatically” evoke prepared responses in others and this information is likely to influence the subsequent behavioural responses of the perceiver (Keltner et al., 2003). With regard to the deficits in social interaction involved in alexithymia, the literature emphasizes that the limited ability to identify and describe subjective feelings in other people leads individuals scoring high on alexithymia to fail to enlist others as sources of aid or comfort (Bagby and Taylor, 1997). These studies were largely retrospective, however. There is clearly a need for further experimental studies looking at potential deficits in emotional mimicry among high alexithymia scorers.

References

Aftanas, L. I., Varlamov, A. A., Reva, N. V., & Pavlov, S. V. (2003). Disruption of early event-related theta synchronization of human EEG in alexithymics viewing affective pictures. *Neuroscience Letters, 340*(1), 57-60.

Bagby, R. M., Parker, J. D. A., & Taylor, G. J. (1994a). The twenty-item Toronto alexithymia scale-I. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research, 38*, 23-32.

Bagby, R. M., & Taylor, G. J. (1997). Affect dysregulation and alexithymia. In G. J. Taylor, R. M. Bagby & J. D. A. Parker (Eds.), *Disorders of affect regulation* (pp. 27-45). Cambridge: Cambridge University Press.

Bagby, R. M., Taylor, G. J., & Parker, J. D. A. (1994b). The twenty-item Toronto Alexithymia Scale-II. Convergent, discriminant, and concurrent validity. *Journal of Psychosomatic Research, 38*, 33-40.

Banse, R. (2001). Affective priming with liked and disliked persons: Prime visibility determines congruency and incongruency effects. *Cognition & Emotion, 15*(4), 501-520.

Bargh, J. A., Chaiken, S., Govender, R., & Pratto, F. (1992). The Generality of the Automatic Attitude Activation Effect. *Journal of Personality and Social Psychology, 62*(6), 893-912.

Bar-On, R., Tranel, D., Denburg, N. L., & Bechara, A. (2003). Exploring the neurological substrate of emotional and social intelligence. *Brain, 126*(Pt 8), 1790-1800.

Bechara, A., Damasio, H. , & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex, 10*, 295-307.

Bechara, A., & Naqvi, N. (2004). Listening to your heart: interoceptive awareness as a gateway to feeling. *Nature Neuroscience, 7*(2), 102-103.

Berthoz, S., Artiges, E., Van de Moortele, P. F., Poline, J. B., Rouquette, S., Consoli, S. M., et al. (2002). Effect of impaired recognition and expression of emotions on frontocingulate cortices: An fMRI study of men with alexithymia. *American Journal of Psychiatry, 159*(6), 961-967.

Blair, R. J. R., Morris, J. S., Frith, C. D., Perrett, D. I., & Dolan, R. J. (1999). Dissociable neural responses to facial expressions of sadness and anger. *Brain, 122*(5), 883-893.

Bower, G. H. (1991). Mood congruity of social judgments. In J. Forgas (Ed.), *Emotion and social judgments* (pp. 31-53). Oxford: Pergamon.

Critchley, H. D. (2004). The human cortex responds to an interoceptive challenge. *Proceedings of the National Academy of Sciences: USA, 101*(17), 6333-6334.

Critchley, H. D., Mathias, C. J., Josephs, O., O'Doherty, J., Zanini, S., Dewar, B. K., et al. (2003). Human cingulate cortex and autonomic control: converging neuroimaging and clinical evidence. *Brain, 126*(Pt 10), 2139-2152.

Critchley, H. D., Melmed, R. N., Featherstone, E., Mathias, C. J., & Dolan, R. J. (2001). Brain activity during biofeedback relaxation: a functional neuroimaging investigation. *Brain, 124*(Pt 5), 1003-1012.

Damasio, A. R. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain*. New-York: Grosset/Putnam.

Damasio, A. R. (1999). *The Feeling of What Happens : Body and Emotion in the Making of Consciousness*. New-York, USA: Harcourt Brace.

de Groot, A. M. B. (1984). Primed lexical decision: Combined effects of the proportion of related prime-target pairs and the stimulus-onset asynchrony of prime and target. *Quarterly Journal of Experimental Psychology, 36A*, 253-280.

Dimberg, U. (1990). Facial Electromyography and Emotional-Reactions. *Psychophysiology, 27*(5), 481-494.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science, 11*(1), 86-89.

Eizaguirre, A. E., de Cabezon, A. O. S., de Alda, I. O., Olariaga, L. J., & Juaniz, M. (2004). Alexithymia and its relationships with anxiety and depression in eating disorders. *Personality and Individual Differences, 36*(2), 321-331.

Fazio, R. H., Sanbonmastu, D. M., Powell, M. C., & Kardes, F. R. (1986). On the automatic activation of attitudes. *Journal of Personality and Social Psychology, 50*, 229-238.

Forgas, J. P. (1994). The role of emotion in social judgments: An introductory review and an Affect Infusion Model (AIM). *European Journal of Social Psychology, 24*, 1-24.

Frawley, W., & Smith, R. N. (2001). A processing theory of alexithymia. *Journal of Cognitive Systems Research, 2*, 189-206.

Frederickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist, 56*, 218-226.

Frederickson, B. L., & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition and Emotion, 12*, 191-220.

Friedlander, L., Lumley, M.A., Farchione, T., & Doyal, G. (1997). Testing the alexithymia hypothesis: Physiological and subjective responses during relaxation and stress. *Journal of Nervous and Mental Disease, 185*, 233-239.

Hermans, D., De Houwer, J., & Eelen, P. (1994). The Affective Priming Effect : Automatic Activation of Evaluative Information in Memory. *Cognition & Emotion, 8*(6), 515-533.

Hermans, D., De Houwer, J., & Eelen, P. (2001). A time course analysis of the affective priming effect. *Cognition & Emotion, 15*(2), 143-165.

Hermans, D., DeHouwer, J., & Eelen, P. (1996). Evaluative decision latencies mediated by induced affective states. *Behaviour Research and Therapy, 34*(5-6), 483-488.

Jula, A., Salminen, K., & Saarijärvi, S. (1999). Alexithymia. A facet of essential hypertension. *Hypertension, 33*, 1057-1061.

Kano, M., Fukudo, S., Gyoba, J., Kamachi, M., Tagawa, M., Mochizuki, H., et al. (2003). Specific brain processing of facial expressions in people with alexithymia: an (H2O)-O-15-PET study. *Brain, 126*, 1474-1484.

Kauhanen, J., Kaplan, G.A., Cohen, R.D., Julkunen, J., & Salonen, J. T. (1996). Alexithymia and risk of death in middle-aged men. *Journal of Psychosomatic Research, 41*, 541-549.

Keltner, D., Ekman, P., Gonzaga, G. C., & Beer, J. (2003). Facial expression of emotion. In R. J. Davidson, K. R. Scherer & H. H. Goldsmith (Eds.), *Handbook of affective sciences* (pp. 415-432). New-York: Oxford University Press.

Klauer, K. C. (1998). Affective priming. In W. Stroebe & M. Hewstone (Eds.), *European Review of Social Psychology* (Vol. 8, pp. 67-103): John Wiley & Sons.

Klauer, K. C., & Stern, E. (1992). How attitudes guide memory-based judgments: A two-process model. *Journal of Experimental Social Psychology, 28*, 186-206.

Lane, R. D., & Schwartz, G. E. (1987). Levels of emotional awareness: A cognitive-developmental theory and its application to psychopathology. *American Journal of Psychiatry, 144*, 133-143.

Lane, R. D., Sechrest, L., Reidel, R., Weldon, V., Kaszniak, A.• , & Schwartz, G. E. (1996). Impaired verbal and nonverbal emotion recognition in alexithymia. *Psychosomatic Medicine, 58*, 203-210.

Leleu, S. (1987). *Un atlas semantique de concepts d'emotion : normes et validation.* Unpublished Graduate Thesis, Université catholique de Louvain, Louvain-la-Neuve, Belgium.

Loas, G., Otmani, O., Verrier, A., Fremaux, D. , & Marchand, M. P. (1996). Factor analysis of the French version of the 20-item Toronto alexithymia scale (TAS-20). *Psychopathology, 29*, 139-144.

Loas, G., Parker, J.D.A., Otmani, O., Verrier, A., & Fremaux, D. (1997). Confirmatory factor analysis of the French translation of the 20-item Toronto Alexithymia Scale. *Perceptual and Motor Skills, 85*, 1018-1018.

Lucas, R. E., Diener, E., & Suh, E. (1996). Discriminant validity of well-being measures. *Journal of Personality and Social Psychology, 71*, 616-628.

Luminet, O., Bagby, R. M., Wagner, H., Taylor, G. J., & Parker, J. D. A. (1999). Relation between alexithymia and the five-factor model of personality: A facet-level analysis. *Journal of Personality Assessment, 73*, 345-358.

Luminet, O., Rimé, B., Bagby, R. M., & Taylor, G. J. (2004). A multimodal investigation of emotional responding in alexithymia. *Cognition & Emotion, 18*, 741-766.

Luminet, O., & Vermeulen, N. (2004). [Alexithymia distribution in a sample of Belgian undergraduates students], *Unpublished raw data*.

Luminet, O., Zech, E., Rimé, B., & Wagner, H.L. (2000). Predicting cognitive and social consequences of emotional episodes: The contribution of emotional intensity, the Five Factor Model and alexithymia. *Journal of Research in Personality, 34*, 471-497.

Lundqvist, D., Esteves, F., & Öhman, A. (1999). The face of wrath: Critical features for conveying facial threat. *Cognition and Emotion, 13,* 691-711.

Marchesi, C., Brusamonti, E., & Maggini, C. (2000). Are alexithymia, depression, and anxiety distinct constructs in affective disorders? *Journal of Psychosomatic Research, 49*(1), 43-49.

Matthews, G., & Harley, T. A. (1996). Connectionist models of emotional distress and attentional bias. *Cognition and Emotion, 10*, 561-600.

Matthews, G., & Wells, A. (2000). Attention, automaticity, and affective disorder. *Behavior Modification, 24*, 69-93.

McDonald, P. W., & Prkachin, K. W. (1990). The expression and perception of facial emotion in alexithymia: A pilot study. *Psychosomatic Medicine, 52*, 199-210.

Messina, D., Morais, J., & Cantraine, F. (1989). Affective value of 904 french nouns. *Cahiers de Psychologie Cognitive - Current Psychology of Cognition, 9*, 165-187.

Neely, J. H. (1991). Semantic priming effects in visual word recognition. In D. Besner & G. Humphreys (Eds.), *Basic processes in reading: Visual word recognition* (pp. 264-337). Hillsdale, NJ: Erlbaum.

Neely, J. H., & Keefe, D. E. (1989). Semantic context effects on visual word processing: A hybrid prospective/retrospective processing theory. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 24, pp. 207-248). New York: Academic Press.

Paez, D., Velasco, C., & Gonzalez, J. L. (1999). Expressive writing and the role of alexithymia as a dispositional deficit in self-disclosure and psychological health. *Journal of Personality and Social Psychology, 77*, 630-641.

Parker, J. D. A., Taylor, G. J., & Bagby, R. M. (2001). The relationship between emotional intelligence and alexithymia. *Personality and Individual Differences, 30*(1), 107-115.

Parker, J. D. A., Taylor, G. J., & Bagby, R. M. (1993). Alexithymia and the recognition of facial expressions of emotion. *Psychotherapy and Psychosomatics, 59*, 197-202.

Porcelli, P., Taylor, G.J., Bagby, R.M., & De Carne, M. (1999). Alexithymia and functional gastrointestinal disorders - A comparison with inflammatory bowel disease. *Psychotherapy and Psychosomatics, 68*, 263-269.

Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology, 61*, 380-391.

Ratcliff, R., & McKoon, G. (1981). Automatic and strategic components of priming in recognition. *Journal of Verbal Learning and Behavior, 20*, 204-215.

Roskos-Ewoldsen, D. R., & Fazio, R. H. (1992). On the orienting value of attitudes: Attitude accessibility as a determinant of an object's attraction of visual attention. *Journal of Personality and Social Psychology, 63*, 198-211.

Schneider, S. L. (2001). In search of realistic optimism: Meaning, knowledge, and warm fuzziness. *American Psychologist, 56*, 250-263.

Suslow, T. (1998). Alexithymia and automatic affective processing. *European Journal of Personality, 12*(6), 433-443.

Suslow, T., Junghanns, K., Donges, U. S., & Arolt, V. (2001). Alexithymia and automatic processing of verbal and facial affect stimuli. *Cahiers De Psychologie Cognitive-Current Psychology of Cognition, 20*(5), 297-324.

Taylor, G. J. (1994). The alexithymia construct: conceptualization, validation, and relationship with basic dimensions of personality. *New Trends in Experimental and Clinical Psychiatry, 10*, 61-74.

Taylor, G. J., & Bagby, R. M. (1988). Measurement of alexithymia - recommendations for clinical-practice and future research. *Psychiatric Clinics of North America, 11*, 351-366.

Taylor, G. J., Bagby, R. M., & Parker, J. D. A. (1997). *Disorders of affect regulation. Alexithymia in medical and psychiatric illness*. Cambridge: Cambridge University Press.

Taylor, G. J., Bagby, R.M. , & Luminet, O. (2000). Assessment of alexithymia: Self-report and observer-rated measures. In R. Bar-On & J. D. A. Parker (Eds.), *The handbook of emotional intelligence: Theory, development, assessment, and application at home, school, and in the workplace* (pp. 301-319). San Fransisco: Jossey-Bass.

Taylor, G. J., Bagby, R.M., & Parker, J. D. A. (1991). The alexithymia construct. *Psychosomatics, 32*, 153-164.

Taylor, G. J., Bagby, R.M., Ryan, D.P., & Parker, J. D. (1990). Validation of the alexithymia construct: A measurement-based approach. *Canadian Journal of Psychiatry, 35*, 290-297.

Todarello, O., Taylor, G. J., Parker, J. D. A., & Fanelli, M. (1995). Alexithymia in essential hypertensive and psychiatric outpatients: A comparative study. *Journal of Psychosomatic Research, 39*, 987-994.

Troisi, A., Delle Chiaie, R., Russo, F., Russo, M. A., Mosco, C., & Pasini, A. (1996). Nonverbal behavior and alexithymic traits in normal subjects: Individual differences in encoding emotions. *Journal of Nervous and Mental Disease, 184*, 561-566.

Vanman, E. J., Dawson, M. E., & Brennan, P. A. (1998). Affective reactions in the blink of an eye: Individual differences in subjective experience and physiological responses to emotional stimuli. *Personality and Social Psychology Bulletin, 24*, 994-1005.

Vermeulen, N., Luminet, O., & Corneille, O. (2004a). Alexithymia does not moderate the ability to find an angry face in the crowd : Evidence from a visual search paradigm. *Manuscript in Preparation*.

Vermeulen, N., Luminet, O., Cordovil de Sousa, M., & Campanella, S. (2004b). Attentional processing of emotional facial expressions in alexithymia: A visual ERP study. *Manuscript submitted for publication*.

Watson, D., Clark, L.A, & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect - The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063-1070.

Wells, A., & Matthews, G. (1996). Modeling cognition in emotional disorder: The S-REF model. *Behaviour Research and Therapy, 34*, 881-888.

Wentura, D. (1999). Activation and inhibition of affective information: Evidence for negative priming in the evaluation task. *Cognition & Emotion, 13*(1), 65-91.

Wise, T. N., & Mann, L. S. (1994). The relationship between somatosensory amplification, alexithymia, and neuroticism. *Journal of Psychosomatic Research, 38*, 515-521.

Wise, T. N., Mann, L. S., & Shay, L. (1992). Alexithymia and the five-factor model. *Comprehensive Psychiatry, 33*, 147-151.

Zung, W. W. (1965). A self-rating depression scale. *Archives of General Psychiatry, 12*, 63-70.

Author Notes

This study was supported by grants 1.5.146.02 and 1.5.123.04 from the Belgian National Fund for Scientific Research granted to Olivier Luminet and by an ARC grant (convention N° 01/06-270) from the French-speaking government. Olivier Luminet is research associate at the National Fund for Scientific Research, Brussels. Nicolas Vermeulen is assistant researcher. Olivier Corneille is professor and research associate at the Catholic University of Louvain in Louvain-la-Neuve. We want to thank François Honée for his help in building the experimental design and in collecting data for the third study. We also want to thank Dirk Hermans, Pierre Philippot, Hugh L. Wagner and an anonymous reviewer for their helpful comments on earlier drafts of this paper.

Correspondence concerning this article should be addressed to Olivier Luminet, Catholic University of Louvain, Department of Psychology, Research Unit for Emotion, Cognition, and Health, 10, Place Cardinal Mercier, B-1348 Louvain-la-Neuve, Belgium, or on e-mail to Olivier.Luminet@psp.ucl.ac.be

Footnotes

1. The Stimulus Onset Asynchrony or SOA refers to the interval between onset of prime and onset of target.

2. Positive and negative nouns were not different in length (i.e. number of letters), F (1, 29) = 1.65, n.s. (positive: M = 5.93, SD = 1.53; negative: M = 6.67, SD = 1.59) or in emotionality (from 1 “not linked to emotion” to 7 “strongly linked to emotion”), F (1, 29) =1.64, n.s. (positive: M = 5.96, SD = 0.34; negative: M = 5.79, SD = 0.41). Positive and negative nouns were strongly different for valence (from -3 “strongly unpleasant” to +3 “strongly pleasant”), F (1, 29) = 2452.90, p < 0.001 (positive: M = 2.31, SD = 0.32; negative: M = -2.60, SD = 0.21). As in the first experiment, we used both verbal and schematic faces as primes. Verbal primes were the same 12 emotional adjectives (for a description and pretests, see material section of the first experiment) and six neutral words (e.g., informed, installed) wich replaced the non-word six-letter strings we used in the first experiment (for word primes, see annexe 1). No differences were found for the length between the three lists of words, F (2, 15) < 1, n.s. (positive: M = 7.16, SD = 1.83; negative: M = 6.83, SD = 0.98; neutral : M = 6.67, SD = 0.82). Analyses were carried out in order to select 18 words for this experiment were based on pretests which were made in previous experiments (Luminet et al., 2004). Judges rated all words on different Likert scales ranging from 0 “not at all” to 6 “extremely”. These pretests showed that there was a main effect of word type on ambiguity, F (2, 15) = 7.94, p < .01. While positive words (M = .99, SD = .95) did not differ from negative words (M = .73, SD = .63), both differed from neutral words (M = 1.79, SD = 1.21). A main effect of word type on concreteness was also observed, F (2, 15) = 8.78, p < .01. Positive words (M = 1.15, SD = 1.16) did not differ from negative words (M = 1.40, SD = 1.46), but both differed from neutral words (M = 2.53, SD = 1.68). These analyses revealed that there

was a main effect for word type on imageability, F (2, 15) = 57.83, $p < .01$. The difference between positive words (M = 3.23, SD = 1.00) and negative words (M = 2.57, SD = 1.22) did not reach significance, but both differed from neutral words (M = 1.10, SD = .69). On the other hand, there was a main effect for word type on emotionality, F (2, 15) = 86.40, $p < .001$. Positive words (M = 4.46, SD = 1.04) did not differ from negative words (M = 4.81, SD = 1.05), but both differed from neutral words (M = .67, SD = .56). A main effect for word type for valence was also observed, F (2, 15) = 150.77, $p < .001$, where positive words (M = 4.97, SD = .56), negative words (M = 1.06, SD = .51), and neutral words (M = 3.07, SD = .26) differed from each other. A dictionary ("Trésor de la langue française") showed that all lists were equivalent for lexical frequency, F (2, 15) = 1.21, n.s. As we expected, positive and negative words differed only for on valence but not for other variables.

3. For the sad face prime, analyses were conducted with Studies 2 and 3 only, because the sad face prime was not used in Study 1.

Table 1

Means, Standard Deviations, Ranges and Skewness for the TAS-20 in the three studies

Scale	Mean	SD	Minimum	Maximum	Skewness
Study 1	49.56	10.94	26	83	0.59
Study 2	49.22	10.72	29	78	0.26
Study 3	47.23	8.26	29	66	0.08

Table 2.

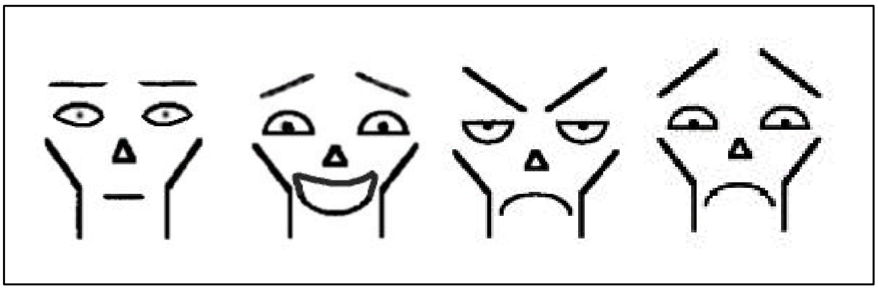
Mean Reaction Times and Standard Deviations for Congruent and Incongruent Pairs of Primes-Targets for Study 1, Study 2 and Study 3

	Study 1				Study 2					Study 3				
	Word primes		Face Primes		Word primes		Face Primes			Word primes		Face Primes		
	Positive	*Negative*	*Happy*	*Angry*	*Positive*	*Negative*	*Happy*	*Sad*	*Angry*	*Positive*	*Negative*	*Happy*	*Sad*	*Angry*
Positive targets	673 ms (102 ms)	717 ms (118 ms)	664 ms (94 ms)	682 ms (113 ms)	615 ms (100ms)	625 ms (75ms)	596 ms (79 ms)	623 ms (77 ms)	633 ms (79 ms)	631 ms (125 ms)	672 ms (135 ms)	650 ms (98 ms)	674 ms (114 ms)	675 ms (122 ms)
Negative targets	730 ms (103 ms)	700 ms (98 ms)	693 ms (104 ms)	675 ms 109 ms)	672 ms (88 ms)	659 ms (80 ms)	642 ms (75 ms)	628 ms (77 ms)	629 ms (84 ms)	706 ms (138 ms)	666 ms (133 ms)	693 ms (110 ms)	689 ms (126 ms)	685 ms (120 ms)

Figure captions

Figure 1. Schematic Neutral, Happy, Angry-Threat and Sad (added for study 2 & 3) faces used as prime (From Lundqvist et al., 1999)

Figure 1



Appendix.

Words used as primes in the experiments. Neutral words were introduced in the second study to replace non-word six-letter strings. Original words are in French, translations are given in the last column.

Type of words	Original material	Translations
Neutral words	Éduqué	Educated
	Initié	Initiated
	Assigné	Allocated
	Éloigné	Distant
	Averti	Informed
	Installé	Installed
Negative words	Accablé	overwhelmed
	Effrayé	Scared
	Hostile	Hostile
	Agacé	Irritated
	Coléreux	quick-tempered
	furieux	Furious
Positive words	Charmé	Charmed
	Émerveillé	Delighted
	Optimiste	Optimistic
	Jovial	Jolly
	Joyeux	Happy
	Exalté	Elated