

Cognition and Neurosciences

Alexithymia is associated with an augmenter profile, but not only: Evidence for anticipation to arousing music

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It has been suggested that high alexithymia scorers have an 'augmenter' profile which amplifies their physiological and subjective responses to highly arousing stimuli. The aim of this study was to test this theory using several physiological measures. Participants listened to musical excerpts either in a 'weak-to-strong' or a 'strong-to-weak' order of arousing levels of stimuli. The results show that alexithymia was associated with an augmenter profile for subjective reports for the most arousing stimulus and with stronger skin conductance level responses in the 'strong-to-weak' order. These results partially support the augmenter profile and reveal that alexithymia may be associated with higher anticipation for the most arousing excerpt.

Key words: Alexithymia, augmenter, arousal, skin conductance, music.

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INTRODUCTION

Alexithymia is defined as a difficulty in identifying, differentiating and describing feelings. Alexithymia is also characterized by an external way of thinking which is oriented towards the pragmatic elements of everyday life (Taylor, 2000). This construct was initially introduced to describe clinical patients with so-called psychosomatic diseases who experienced difficulties describing their emotions and who presented impoverished mental representations of their emotional states. Moreover, individuals who score high on alexithymia tend to have poor affect regulation (e.g., Taylor, Bagby & Parker, 1997). A high prevalence of alexithymia has been observed in some somatic diseases such as cardiovascular problems (e.g., Numata, Ogata, Oike, Matsumura & Shimada, 1998). Alexithymia is also associated with an impaired ability to recognize bodily sensations (e.g., Herbert, Herbert & Pollatos, 2011), and is well represented in somatization (for a review: Lumley, Neely & Burger, 2007). Somatization is characterized by high amounts of somatic complaints and amplification and misinterpretation of somatic sensations as signs of physical illness (Lundh & Simonsson-Sarnecki, 2001).

Lumley *et al.* (2007) proposed that alexithymia is related to an amplification of sensations of physical and proprioceptive stimuli. This suggests that greater reports (over-reporting) of physical complaints among high alexithymia scorers (HA) (e.g., Wearden, Lambertson, Crook & Walsh, 2005), might result from higher sensitivity to somatic sensations without physical illness. Indeed, HA show a lower tolerance to touch (Sivik, 1993) and report, with auto-evaluative questionnaires, somatosensory amplification (e.g., Wise & Mann, 1994; Nakao, Barsky, Kumano & Kuboki, 2002; Sayar, Kirmayer & Taillefer, 2003). As somatosensory amplification is hypothesized to be linked with somatization (Barsky, 1992), it has been suggested that somatosensory amplification

could mediate the associations between alexithymia and somatization (Wise & Mann, 1994).

Research has also shown that somatosensory amplification is stronger in HA, but only for intense stimulation. While HA have similar pain thresholds for weak pain stimuli as low alexithymia scorers (LA), they have a lower tolerance to highly painful stimuli (Nyklicek & Vingerhoets, 2000; Huber, Suman, Biasi & Carli, 2009). In line with these results, some authors have suggested that HA demonstrate an 'augmenter' profile, while low LA would have a 'reducer' profile (Morrison & Pihl, 1990; Schäfer, Schneider, Tress & Franz, 2007). According to the reducing/augmenting theory, augmenters amplify their psychophysiological responses and their subjective responses to arousing sensory stimulations, while reducers attenuate them (Morrison & Pihl, 1990; Larsen & Zarate, 1991). Reducers adopt regulation strategies, which allow them to reduce their arousal at high levels of a given stimulus, while augmenters are generally more vulnerable to highly arousing stimulation (Schäfer *et al.*, 2007).

Evidence for the augmenter profile of HA is strengthened by several studies that found that HA had a lower tolerance to the strongest, pain stimuli compared to LA (e.g., Kano, Hamaguchi, Itoh, Yanai & Fukudo, 2007). Moreover, when administered, the strongest pain stimulation HA, exhibited higher levels of stress-related hormones relative to LA and higher brain activation in regions typically activated during visceral stimulation (Kano *et al.*, 2007). HA also report higher pain and anxiety but only during strongest stimulation. Schäfer *et al.* (2007) manipulated the sound intensity (dB) of white noises and showed that the amplitudes of the attentional neurophysiological components were larger only in HA during intense stimuli, which meant that they were more alert and allocated more attentional resources to these stimuli. This augmentation of their physiological reactivity may lead HA to over-report somatic sensations and thus to acquire the somatoform disorder (Schäfer *et al.*, 2007). One of the challenges of diagnosing

somatoform disorder is to distinguish complaints associated with non-intentional over-reporting of health problems (the actual somatoform disorder) from intentional over-reporting of health problems (malingering of negative symptoms). The changes of arousal patterns associated with alexithymia may provide an objective indicator to help properly diagnose individuals. We hypothesize that higher sensitivity to arousing stimuli (i.e., augmenting pattern) and an impaired ability to regulate emotional experiences are important predictors of somatoform disorder in HA.

Previous research has examined the augmenter profile of HA through their brain activity and stress-related hormonal responses to simple physical stimulations. In contrast to this method, Roedema and Simons (1999) aimed to investigate the feelings and autonomic responses of HAs when presented images that varied in emotional arousal and valence. They showed that HA subjectively assessed the images as less arousing and produced fewer skin conductance and less heart rate deceleration responses. Thus, their results suggested a psychophysiological and subjective 'reducer' profile in HA. Thus, whereas the majority of studies report data supporting the augmenter view, this work by Roedema and Simons (1999) found the opposite. We believe that this indicates the existence of moderators, such as, for example, the emotional context: HA might not present an augmenter profile when they are exposed to arousing stimuli contaminated by different emotional contexts (different levels of arousal and different valences).

The dearth of research examining the augmenter profile at a physiological level has motivated the present study. Our aim is to assess the autonomic activity state of HA when exposed to unpleasant stimuli while varying the stimuli's arousability level. Unlike Roedema and Simons (1999), we used short unpleasant musical excerpts possessing a higher potential to evoke stronger emotional arousal compared to pictures. Indeed, it was shown that musical stimuli present an important effect of emotional responses as they increase the emotional significance of affective pictures (Baumgartner, Lutz, Schmidt & Jäncke, 2006). Additionally, one recent study found that HA were specifically disturbed by a discretely played anger/fear-related (i.e., high arousal) music but not when happy music was displayed (Vermeulen, Toussaint & Luminet, 2010).

Besides our main interest for the assessment of the augmenter profile of HA, the present study also raises two other issues related to the Sympathetic Nervous System activity that might have an impact on somatic and somatoform illnesses: habituation and recovery. Habituation is defined as response diminution or extinction after repeated presentation of a stimulus (e.g., Öhman, Hamm & Hugdahl, 2000). It is usually faster for weakly, as opposed to highly arousing stimuli (Thompson & Spencer, 1960). We hypothesized a slower habituation among HA compared to LA when several stimuli are presented sequentially. Investigating this issue among this population is critical because slow habituation to painful stimuli has been associated with the development of chronic pain (Flor, Diers & Birbaumer, 2004). Only one study has been carried out before on this issue, and it failed to find an alexithymia effect on overall habituation during the presentation of two unpleasant movies (Franz, Schaefer & Schneider, 2003). It is also worth mentioning that Franz *et al.* (2003) did not manipulate arousal, a factor which may significantly influence physiological habituation (Thompson & Spencer, 1960). In order

to assess how alexithymia is associated with habituation abilities, the arousal-related component was manipulated with a 'weak-to-strong' and a 'strong-to-weak' order of arousal change.

Recovery refers to the period that follows presentation of the stimuli. We hypothesized that higher levels of alexithymia would be associated with slower recovery rates. Higher levels of alexithymia have already been associated with slower recovery after a stressful task (Friedlander, Lumley, Farchione & Doyal, 1997), and after the recall of memories associated with outbursts of anger (Neumann, Sollers, Thayer & Waldstein, 2004). Delays in recovering from unpleasant stimuli are associated with higher risks of developing stress-related illnesses (e.g., Brosschot & Thayer, 1998).

MAIN HYPOTHESES

1. *Alexithymia's augmenter profile for physiological and subjective responses*

We hypothesized that HA would demonstrate higher autonomic activation and would report stronger subjective reaction than LA for the most arousing musical excerpt, independently of the order of arousing stimuli presentation. Using correlational analysis, we expected that higher level of alexithymia to be associated with higher physiological and subjective responses to the most arousing excerpt, independently of the order of such excerpt presentation (i.e., in both the first, and the last order positions).

2. *Alexithymia's habituation abilities*

We hypothesized that the increase (decrease) of autonomic responses would be stronger (weaker) in the HA compared to the LA, in the 'increasing' ('decreasing') condition of arousing stimuli presentation order. Using regression analyses, we expected that the interaction between order and alexithymia would predict the physiological responses for each excerpt.

3. *Alexithymia's recovery abilities*

We hypothesized that HA would present higher physiological reactivity than LA during the recovery period, especially after the 'increasing' condition. Using regression analyses, we expected that the interaction between order and alexithymia would predict the physiological activity during the recovery period.

Method

Participants. Twenty-seven female students (mean age, $M = 21.60$; $SD = 1.47$) at the Université catholique de Louvain, Louvain la Neuve, were tested. They were recruited by announcements across the university campus and were paid 7 euros for their participation.

Physiological recording equipment. The cardiovascular system activity was measured by continuous recording of electrocardiogram using two standard Ag/AgCl electrodes (Biopac System, Santa Barbara, CA) filled with Biopac electrode gel and placed on

the participant's forearms. The signal was amplified and filtered by a Biopac bioamplifier with high and low cutoffs set at 40 and 8 Hz, respectively, and was sampled at 2,000 Hz via a Biopac A/D converter controlled by the AcqKnowledge software (Biopac System, Santa Barbara, CA). In addition, an infrared transducer was attached to the distal phalanx of the middle finger of the right hand, and beat-to-beat pulse volumes were measured using a peripheral pulse amplifier (Contact Precision Instruments, London) and sampled at 2,000 Hz. The interbeat intervals (IBI) were calculated as the time in milliseconds between successive R waves in the electrocardiogram and were edited for outliers (artifacts or ectopic myocardial activity). Finger pulse volume (PV), the trough-to-peak amplitude (in volts) of each finger pulse, was measured.

Skin conductance levels (SCL) were recorded using two Ag/AgCl electrodes with a 0.05 molar NaCl electrolyte. Electrodes were placed on the distal phalanges of the index and third finger of the left hand. A constant voltage of 0.5 V was applied across the electrodes and skin conductance was measured using a Biopac preamplifier sampled at 125 Hz. The signal was calibrated to detect activity in the range from 0 to 20 microsiemens (μ S) range.

The data processing of physiological signals was performed off-line with customized interactive computer programs written in the Spike2 programming environment (Cambridge Electronic Design, Cambridge; programming by Dmitry Davydov, see Davydov, Shapiro, Cook & Goldstein, 2007, Davydov, Zech & Luminet, 2011).

The activity of each autonomic measure was defined as the difference between the mean scores during the presentation of the musical excerpt and of the 30 seconds before the start of the musical excerpt (the last 30 seconds of the 3-minute rest periods between each excerpt). We considered the latter period as a baseline for the following stimulation. In testing our third hypothesis we used raw mean scores for the recovery period.

Musical excerpts. All five selected musical excerpts have been shown in previous research to elicit negative emotions and to vary in the level of arousal they produced when rated on a 9-point Likert scale (Gomez & Danuser, 2004). The musical excerpts were as follows (from strongest to weakest arousal): 1. Manowar, Hail to England – Black Arrows; 2. S. Barber, Adagio for strings Op. 11; 3. D. Borgir, Puritanical Euphoric Misanthropy – Fear and Wonder; 4. G. Mahler, Symphony No. 5 – Adagietto; and 5. M. Ravel, Piano Concerto in G major – Adagio assai (respective arousal: 8.29; 6.48; 4.19; 2.74; 1.97; Gomez & Danuser, 2004). We attempted to manipulate the level of arousal through selection of a synergetic combination of the sound intensity of stimuli and their dissonance attribute using information from Gomez and Danuser's database (2004). In the present study, music intensity was re-evaluated by a dB meter and adjusted to be as close as possible to the intensity reported by Gomez and Danuser (2004) at the chosen distance between a subject and speakers.

Half of the sample listened to the musical excerpts in the increasing order of arousal (weak-to-strong) and the other half to the musical excerpts were presented in decreasing order (strong-to-weak).

Questionnaires. The Toronto Alexithymia Scale Twenty Item (TAS-20; Bagby, Parker & Taylor, 1994; French version: Loas,

Otmani, Verrier, Fremaux & Marchand, 1996), consists of 20 items measuring three dimensions of alexithymia: Difficulty Identifying Emotions (e.g., 'I am often confused about what emotion I am feeling'); Difficulty Describing Emotions (e.g., 'It is difficult for me to find the right words for my feelings'); and Externally Oriented Thinking (e.g., 'I prefer talking to people about their daily activities rather than their feelings'). The French version has good reliability and validity with an internal consistency of 0.73 for the total score (Loas *et al.*, 1996).

A Valence, Arousal, Somatic and Mood Questionnaire (VASMQ) was created to measure participants' subjective assessment of each excerpt. They were asked to rate the valence and arousal of each excerpt on a 7-point Likert scale (one valence item: 'how pleasant or unpleasant was the excerpt' - Range: 0–6; one arousal item: 'how strong was the emotional arousal you felt during the musical excerpt' - Range: 0–6). They were also asked to rate on a 7-point Likert scale their somatic sensations (13 items; e.g., 'I felt shaky' - Range: 0–78) and mood (2 positive - Range 0–12 - and 5 negative items - Range: 0–30; e.g., 'I felt happy, excited, and beaming; 'I felt sad and depressed') after each excerpt. The internal consistency of the somatic scale ranged from 0.66 to 0.78, that of the positive mood scale from 0.72 to 0.84, and that of the negative mood scale from 0.71 to 0.84.

Procedure. The participants were tested individually. They were seated in a comfortable chair positioned 1.5 meters from the speakers. Each participant was told to relax for 5 minutes before the playing of the first musical excerpt. The five musical excerpts were then played with 3-minute rest periods between them. At the end of each excerpt, the experimenter entered the room and asked the participant to complete the VASMQ. After all the stimuli had been presented, the participant's physiological activity was recorded during a two-minute recovery period. Finally, the participant was asked to complete the TAS-20.

RESULTS

The significance level was set at $p < 0.05$. No significant effect of order and alexithymia was found for IBI and PV. Consequently, we did not report the corresponding data.

Hypothesis 1 was examined with Pearson correlations between alexithymia, the SCL and the subjective responses to the most arousing excerpt. For this aim, we created new variables: we considered the SCL and subjective responses to the first excerpt for one half of the sample (decreasing order condition) and to the last excerpt for the other half (increasing order condition). Hypotheses 2 and 3 were examined for each excerpt by hierarchical regression analyses, in which the physiological and subjective responses (for hypothesis 2 only) were regressed on the order, alexithymia TAS-20 total score and the interaction between alexithymia and order. We used contrast codes (–1 for decreasing order and +1 for increasing order) and centered alexithymia score.

Descriptive data

The mean (standard deviation) of TAS-20 total score was 54.33 (11.56), which is highly comparable to previous studies using larger samples (e.g., Vermeulen, Luminet & Corneille 2006;

Vermeulen *et al.*, 2010). Descriptive data of psychophysiological and subjective responses for each excerpt are reported in Table 1.

Hypothesis 1

Physiological responses to the most arousing stimulus were not predicted by TAS-20 total score. However, the TAS-20 total score was associated with higher reports of negative mood for the most arousing stimulus ($r = 0.52$; $p = 0.005$), and near significant with high reports of somatic sensations ($r = 0.38$; $p = 0.053$) and low reports of positive mood ($r = -0.37$; $p = 0.06$). There were no relations for the less intense stimuli, except a positive correlation between alexithymia and negative mood for the third excerpt ($r = 0.48$; $p < 0.02$). Thus, alexithymia was associated with an augmenter profile at the subjective level only.

Hypothesis 2

The regression model for the first excerpt was significant ($F(3, 26) = 8.24$; $p = 0.001$) and showed that SCL response to the first excerpt was significantly predicted by order ($\beta = -0.55$; $t = -3.79$; $p = 0.001$), TAS-20 total score ($\beta = 0.32$; $t = 2.23$; $p < 0.04$) and by its interaction with order ($\beta = -0.33$; $t = -2.27$; $p < 0.04$). The SCL response to first excerpt was higher during the decreasing (vs. increasing) arousal order condition and was associated with higher level of alexithymia. The analysis of the interaction revealed that SCL response was positively associated with TAS-20 total score, during the decreasing arousal order ($r = 0.58$; $p < 0.04$) but not during the increasing order ($r = -0.02$; $p = 0.95$). Thus, high alexithymia scores were associated with higher physiological activation in response to the most arousing stimulus in comparison with low alexithymia

Table 1. Descriptive data of physiological and subjective reports for each excerpt dependently or independently of order

Excerpts		Decreasing order		Increasing order		Independently of order	
		Mean	SD	Mean	SD	Mean	SD
1	Skin conductance level (μ S)	0.14	0.21	0.82	0.73	0.46	0.62
	Pulse volume (V)	-0.38	0.73	-0.77	1.12	-0.57	0.94
	Interbeat interval (ms)	0.00	0.06	0.01	0.03	0.00	0.04
	Somatic sensations	20.38	10.08	13.29	9.26	16.70	10.14
	Valence	0.54	1.13	4.29	1.14	2.48	2.21
	Arousal	3.31	1.65	2.93	1.33	3.11	1.48
	Positive mood	7.69	4.77	6.29	4.21	6.96	4.46
	Negative mood	10.31	7.48	2.93	2.62	6.48	6.58
2	Skin conductance level (μ S)	0.02	0.08	0.26	0.37	0.11	0.29
	Pulse volume (V)	-0.29	0.32	-0.31	0.66	-0.30	0.50
	Interbeat interval (ms)	0.00	0.05	0.03	0.04	0.01	0.05
	Somatic sensations	15.00	8.64	12.86	7.10	13.88	7.80
	Valence	3.08	1.80	4.43	1.28	3.78	1.67
	Arousal	3.69	1.38	3.36	0.74	3.52	1.09
	Positive mood	4.77	3.37	4.50	3.11	4.63	3.18
	Negative mood	5.85	5.44	2.79	2.67	4.26	4.43
3	Skin conductance level (μ S)	0.1	0.22	0.22	0.21	0.16	0.22
	Pulse volume (V)	-0.20	0.89	-0.32	0.79	-0.26	0.83
	Interbeat interval (ms)	0.01	0.04	0.00	0.02	0.00	0.03
	Somatic sensations	15.31	7.85	14.64	10.31	14.96	9.04
	Valence	3.69	1.60	3.21	1.63	3.44	1.60
	Arousal	3.31	2.02	4.00	1.04	3.67	1.59
	Positive mood	3.00	3.42	3.57	4.09	3.30	3.72
	Negative mood	7.85	7.53	5.29	4.68	6.52	6.23
4	Skin conductance level (μ S)	0.14	0.33	0.07	0.27	0.04	0.31
	Pulse volume (V)	-0.17	0.69	-0.25	0.93	-0.21	0.80
	Interbeat interval (ms)	0.00	0.05	0.00	0.04	0.00	0.04
	Somatic sensations	13.61	7.44	14.86	9.47	14.26	8.42
	Valence	5.08	0.67	1.71	1.27	3.27	1.99
	Arousal	3.62	1.45	3.86	1.17	3.74	1.29
	Positive mood	6.77	3.11	3.29	2.97	4.96	3.47
	Negative mood	0.85	0.99	6.79	4.73	3.93	4.56
5	Skin conductance level (μ S)	0.73	1.17	0.06	0.14	0.34	0.91
	Pulse volume (V)	-0.48	0.80	0.31	0.86	-0.09	0.91
	Interbeat interval (ms)	0.00	0.06	0.01	0.06	0.01	0.06
	Somatic sensations	10.92	7.42	20.29	9.86	15.78	9.83
	Valence	5.31	1.03	0.36	0.63	2.74	2.65
	Arousal	3.85	1.72	3.93	1.73	3.89	1.69
	Positive mood	6.31	4.07	5.14	3.51	5.70	3.76
	Negative mood	0.92	1.44	9.50	6.49	5.37	6.41

Note: μ S: microsiemens; V: Volts; ms: milliseconds.

scores, but only when the most arousing stimulus was presented first.

Hypothesis 3

The model was not significant ($F(3, 25) = 2.75$; $p = 0.07$). Recovery was thus not predicted by alexithymia and/or order of presentation.

DISCUSSION

Augmenting and habituation

This study was conducted to assess whether HA were augmenters at physiological and subjective levels. The augmenter profile is associated with the tendency to show increased responses to highly arousing stimuli, while reducers tend to diminish their responses when exposed to highly arousing stimuli. Our results did not support the hypothesis that a higher level of alexithymia was associated with higher SCL response for the most arousing stimulus in general. However, the response to the most arousing stimulus was associated with higher negative affect, higher somatic sensations and lower positive affect. This confirms the results of Kano *et al.* (2007) supporting the augmenting hypothesis for subjective responses. The HA's tendency to report higher negative feelings is thus in line with their greater reports of somatic complaints (Lumley *et al.*, 2007). This is also consistent with Papciak, Feurestein & Spiegel's (1985) 'decoupling' concept, which states alexithymia is characterized by a discrepancy between the subjective reports and the physiological activity in response to arousing stimuli. Alexithymia was found to be related to a decoupling between physiological and experiential awareness (see also Stone & Nielsen, 2001; Luminet, Rime, Bagby & Taylor, 2004).

Our results also showed that HA exhibit higher SCL responses to the first excerpt independently of its arousal level. Though the effect was more pronounced when the first excerpt was the most arousing one, it suggested that alexithymia seemed to affect the specific mechanism of orienting responses to the initial and novel stimulus. Orienting responses refer to the increasing of SCL responses to a novel or significant stimuli (Dawson, Schell & Fillion, 2000), and is moderated by personality factors (e.g., Perry, Felger & Braff, 1998).

In the present study, arousing levels of stimuli were mainly evident in SCL responses, and were absent for IBI and PV responses. Previous research has also shown that SCL is the main index of reactivity to musical stimuli (Gomez & Danuser, 2004), but cardiovascular responses are more responsive to challenges demanding not passive (like in the present study), but active involvement in affective, cognitive or physical task processing (e.g., Ottaviani, Shapiro, Davydov & Goldstein, 2008; Davydov *et al.*, 2011). This may explain why only SCL was sensitive to variability in the arousing unpleasantness of music, while heart rate and pulse volume were not.

The absence of augmenting responses in HA for the most arousing stimulus presented at the end of the sequence (an increasing arousal order) may be attributed to the order of

arousability manipulation. That is, besides the habituation mechanism, lower autonomic orienting responses to the most arousing stimulus in the increasing order of stimuli's arousability, could be also explained by the anticipation effect, which is known to enhance SCL before the task (Spinks, Blowers & Sheck, 1985). Moreover, HA present higher levels of negative anticipation of potential stresses, as shown recently by their higher baseline levels of cortisol before being exposed to stressful tasks (de Timary, Roy, Luminet, Fillée & Mikolajczak, 2008). Future research should conduct a complete random experimental design in order to disentangle the augmenting hypothesis of alexithymia from the 'anticipation of stress' hypothesis.

Using skin conductance measures, Roedema and Simons (1999) found a 'reducer' profile in HA. The different nature of the stimuli in respect to their arousal and valence variations might explain the discrepancy between their results and ours. Musical stimuli may produce stronger changes in arousal than the pictures used by Roedema and Simons (1999).

Recovery

It was hypothesized that HA would recover from arousal more slowly than LA. However, our findings showed that the decrease in activation was not related to alexithymia levels, which contradict previous results (Neumann *et al.*, 2004). Future studies should utilize longer and higher arousing stimuli in order to better understand how alexithymia may moderate recovery rates.

Strengths and limitations of this study

To the best of our knowledge, this study was the first to manipulate the order of gradual induction of arousal changes to investigate the augmenter/reducer theory in alexithymia. Three physiological dimensions were analyzed in order to examine and compare three different indicators of arousal. We also investigated subjective reports of valence and arousal, and enlarged this investigation to cover mood and somatic responses. The complexity of the musical stimuli makes it difficult to control just one of their attributes. Gomez and Danuser (2004; 2007) found that musical characteristics such as sound intensity (dB), tempo, rhythm, accentuation, rhythmic articulation, pitch level and range, and consonance could all influence arousal and thus, in turn, skin conductance responses. They also showed that the tempo and the rhythm were associated with heart rate variations. In the musical stimuli we chose, the linear increasing of the arousal detected by SCL followed the increasing levels of intensity (dB) and dissonance (i.e., sound non-stability). Therefore, in the present study we manipulated the arousal level through synergetic manipulation of the music intensity and the consonance/dissonance attribute. Thus, we cannot confidently attribute the detected arousal effect to either sound intensity, consonance/dissonance or their synergetic combination. Only two studies have investigated the effect of sound intensity manipulation on SCL responses (Wilson & Aiken, 1977; Gomez & Danuser, 2007). However, their findings were inconsistent, which suggests that future studies are needed to clarify this issue. As a second limitation, the number of participants in this study was fairly small, as well as the ratio between the sample size and the predictors (9:1). Even though this ratio

was almost satisfactory (10:1; Halinski and Feldt, 1970) the risk of Type I error might be too high. The use of a student sample does not allow us to draw strong conclusions about the explanatory role of the augmeter profile of HA to account for their high prevalence in psychosomatic illnesses. For better representativeness, future studies should collect data from clinical subjects, both males and females. Because males and females may present different patterns of physiological reactivity in emotional tasks (e.g., Kring & Gordon, 1998), our small sample prevented us from enlarging it to include males without biasing our results. Finally, despite the impossibility to make causal inference, we assumed that listening to the musical excerpts could not significantly influence the alexithymia scores, as alexithymia has frequently demonstrated its absolute and relative stability (e.g., Luminet, Bagby & Taylor, 2001; Luminet, Rokbani, Ogez & Jadoulle, 2007; de Timary, Luts, Hers & Luminet, 2008).

Further investigation on a larger sample is thus clearly needed to draw stronger conclusions about the augmeter profile of HA and disentangle it with the anticipation of stress hypothesis, and to focus on clinical populations with somatoform disorders.

REFERENCES

- Bagby, R. M., Parker, J. D. A. & Taylor, G. J. (1994). The 20-item Toronto Alexithymia Scale: Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research*, 38, 23–32.
- Barsky, A. J. (1992). Amplification, somatization, and the somatoform disorders. *Psychosomatics*, 33, 28–34.
- Baumgartner, T., Lutz, K., Schmidt, C. F. & Jäncke, L. (2006). The emotional power of music: How music enhances the feeling of affective pictures. *Brain Research*, 1075, 151–164.
- Brosschot, J. F. & Thayer, J. F. (1998). Anger inhibition, cardiovascular recovery and vagal function: A model of the link between hostility and cardiovascular disease. *Annual Behaviour Medical*, 20, 326–332.
- Davydov, D. M., Shapiro, D., Cook, I. A. & Goldstein, I. (2007). Baroreflex mechanisms in major depression. *Progress in Neuro-Physiopharmacology & Biological Psychiatry*, 31, 164–177.
- Davydov, D. M., Zech, E. & Luminet, O. (2011). Affective context of sadness and physiological response patterns. *Journal of Psychophysiology*, 25, 67–80.
- Dawson, M., Schell, A. & Filion, D. (2000). The electrodermal system. In J. Cacioppo, L. Tassinary & G. Berntson (Eds.), *Handbook of psychophysiology* (2nd edn., pp. 200–223). New York: Cambridge University Press.
- de Timary, P., Luts, A., Hers, D. & Luminet, O. (2008a). Absolute and relative stability of alexithymia in alcoholic inpatients undergoing alcohol withdrawal: Relationship to depression and anxiety. *Psychiatry Research*, 157, 105–113.
- de Timary, P., Roy, E., Luminet, O., Fillée, C. & Mikolajczak, M. (2008b). The moderating impact of alexithymia and alexithymia factors on stress-induced salivary cortisol level in men. *Psychoneuroendocrinology*, 33, 1160–1164.
- Flor, H., Diers, M. & Birbaumer, N. (2004). Peripheral and electrocortical responses to painful and non-painful stimulation in chronic pain patients, tension headache patients and healthy controls. *Neuroscience Letters*, 361, 147–150.
- Franz, M., Schaefer, R. & Schneider, C. (2003). Psychophysiological response patterns of high and low alexithymics under mental and emotional load conditions. *Journal of Psychophysiology*, 17, 203–213.
- 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.
- Gomez, P. & Danuser, B. (2004). Affective and physiological responses to environmental noises and music. *International Journal of Psychophysiology*, 53, 91–103.
- Gomez, P. & Danuser, B. (2007). Relationships between musical structure and psychophysiological measures of emotion. *Emotion*, 7, 377–387.
- Halinski, R. S. & Feldt, L. S. (1970). The selection of variables in multiple regression analyses. *Journal of Educational Measurement*, 7, 151–158.
- Herbert, B. M., Herbert, C. & Pollatos, O. (2011). On the relationship between interoceptive awareness and alexithymia: Is interoceptive awareness related to emotional awareness? *Journal of Personality*, 79, 1149–1175.
- Huber, A., Suman, A. L., Biasi, G. & Carli, G. (2009). Alexithymia in fibromyalgia syndrome: Associations with ongoing pain, experimental pain sensitivity and illness behavior. *Journal of Psychosomatic Research*, 66, 425–433.
- Kano, M., Hamaguchi, T., Itoh, M., Yanai, K. & Fukudo, S. (2007). Correlation between alexithymia and hypersensitivity to visceral stimulation in human. *Pain*, 132, 252–263.
- Kring, A. M. & Gordon, A. H. (1998). Sex differences in emotion: Expression, experience, and physiology. *Journal of Personality and Social Psychology*, 74, 686–703.
- Larsen, R. J. & Zarate, M. A. (1991). Extending reducer/augmeter theory into the emotion domain: The role of affect in regulating stimulation level. *Personality & Individual Differences*, 12, 713–723.
- Loas, G., Otmani, O., Verrier, A., Fremaux, D. & Marchand, M. P. (1996). Factor analysis of the French version of the 20-Item Alexithymia Scale (TAS-20). *Psychotransitionology*, 29, 139–144.
- Luminet, O., Bagby, R. M. & Taylor, G. J. (2001). An evaluation of the absolute and relative stability of alexithymia in patients with major depression. *Psychotherapy and Psychosomatics*, 70, 254–260.
- Luminet, O., Rime, B., Bagby, R. M. & Taylor, G. J. (2004). A multimodal investigation of emotional responding in alexithymia. *Cognition & Emotion*, 18, 741–766.
- Luminet, O., Rokbani, L., Ogez, D. & Jadoulle, V. (2007). An evaluation of the absolute and relative stability of alexithymia in women with breast cancer. *Journal of Psychosomatic Research*, 62, 641–648.
- Lumley, M. A., Neely, L. C. & Burger, A. J. (2007). The assessment of alexithymia in medical settings: Implications for understanding and treating health problems. *Journal of Personality Assessment*, 89, 230–246.
- Lundh, L. G. & Simonsson-Sarnecki, M. (2001). Alexithymia, emotion and somatic complaints. *Journal of Personality*, 69, 483–510.
- Morrison, S. L. & Pihl, R. O. (1990). Alexithymia and stimulus augmenting/reducing. *Journal of Clinical Psychology*, 46, 730–736.
- Nakao, M., Barsky, A. J., Kumano, H. & Kuboki, T. (2002). Relationship between somatosensory amplification and alexithymia in a Japanese psychosomatic clinic. *Psychosomatics*, 43, 55–60.
- Neumann, S. A., Sollers, J. J., Thayer, J. F. & Waldstein, S. R. (2004). Alexithymia predicts attenuated autonomic reactivity, but prolonged recovery to anger recall in young women. *International Journal of Psychophysiology*, 53, 198–195.
- Numata, Y., Ogata, Y., Oike, Y., Matsumura, T. & Shimada, K. (1998). Psychobehavioral factor, alexithymia, is related to coronary spasm. *Japanese Circulation Journal—English Edition*, 62, 409–413.
- Nyklicek, I. & Vingerhoets, A. J. J. M. (2000). Alexithymia is associated with low tolerance to experimental painful stimulation. *Pain*, 85, 471–475.
- Öhman, A., Hamm, A. & Hugdahl, K. (2000). Cognition and the autonomic nervous system. Orienting, anticipation and conditioning. In J. T. Cacioppo, L. G. Tassinary & G. G. Berntson (Eds.), *Handbook of Psychophysiology* (2nd edn., pp. 533–575). Cambridge: Cambridge University Press.
- Ottaviani, C., Shapiro, D., Davydov, D. M. & Goldstein, I. B. (2008). Autonomic stress response modes and ambulatory heart rate level and variability. *Journal of Psychophysiology*, 22, 28–40.

- Papciak, A. S., Feuerstein, M. & Spiegel, J. A. (1985). Stress reactivity in alexithymia: Decoupling of physiological and cognitive responses. *Journal of Human Stress*, 11, 135–142.
- Perry, W., Felger, T. & Braff, D. L. (1998). The relationship between skin conductance hyporesponsivity and perseverations in schizophrenia patients. *Biological Psychiatry*, 44, 459–465.
- Roedema, T. M. & Simons, R. F. (1999). Emotion-processing deficit in alexithymia. *Psychophysiology*, 36, 379–387.
- Sayar, K., Kirmayer, L. J. & Taillefer, S.S. (2003). Predictors of somatic symptoms in depressive disorder. *General Hospital Psychiatry*, 25, 108–114.
- Schäfer, R., Schneider, C., Tress, W. & Franz, M. (2007). Cortical augmenting in alexithymic subjects after unpleasant acoustic stimulation. *Journal of Psychosomatic Research*, 63, 357–364.
- Sivik, T. (1993). Alexithymia and hypersensitivity to touch and palpation. *Integrative Physiological and Behavioral Science*, 28, 130–136.
- Spinks, J. A., Blowers, G. H. & Sheck, D. T. L. (1985). The role of the orienting response in the anticipation of information: A skin conductance response study. *Psychophysiology*, 22, 385–394.
- Stone, L. A. & Nielson, K. A. (2001). Intact physiological response to arousal with impaired emotional recognition in alexithymia. *Psychotherapy and Psychosomatics*, 70, 92–102.
- Taylor, G. J. (2000). Recent developments in alexithymia theory and research. *Canadian Journal of Psychiatry*, 45, 134–142.
- Taylor, G. J., Bagby, R. M. & Parker, J. D. A. (1997). *Disorders of affect regulation: Alexithymia in medical and psychiatric illness*. New York: Cambridge University Press.
- Thompson, R. F. & Spencer, W. A. (1960). Habituation: A model phenomenon for the study of neuronal substrates of behaviour. *Psychological Review*, 73, 16–43.
- Vermeulen, N., Luminet, O. & Corneille, O. (2006). Alexithymia and the automatic processing of affective information: Evidence from the affective priming paradigm. *Cognition & Emotion*, 20, 64–91.
- Vermeulen, N., Toussaint, J. & Luminet, O. (2010). The influence of alexithymia and music on the incidental memory for emotion words. *European Journal of Personality*, 24, 551–568.
- Wearden, A. J., Lambert, N., Crook, N. & Walsh, V. (2005). Adult attachment, alexithymia, and symptom reporting: An extension to the four category model of attachment. *Journal of Psychosomatic Research*, 58, 279–288.
- Wilson, C. V. & Aiken, L. S. (1977). The effect of intensity levels upon physiological and subjective affective responses to rock music. *Journal of Music Therapy*, 14, 60–76.
- Wise, T. N. & Mann, L. S. (1994). The Relationship between somatosensory amplification, alexithymia, and neuroticism. *Journal of Psychosomatic Research*, 38, 515–521.

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