Article

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Autonomic responding to aversive words without conscious valence discrimination

Laetitia Silvert[a,b], Sylvain Delplanque[a], Hammou Bouwalerh[a], Charlotte Verpoort[a], Henrique Sequeira[a,*]

[a] *Neurosciences, Université de Lille 1, Bât. SN4, 59 655 Villeneuve d'Ascq Cedex, France*
[b] *Equipe Temps, Emotion et Cognition, Université de Lille 3, France*

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Abstract

A growing body of data suggests that the emotional dimension of a stimulus can be processed without conscious identification of the stimulus. The arousal system could be activated by unrecognised biologically significant stimuli through simple physical stimulus features related to threat, without any evaluation of the meaning of the stimulus. However, unconscious processing of emotionally laden words cannot rely only on perceptual features but must include some analysis of symbolic meaning. The first aim of the present study was to assess whether masked (unrecognised) aversive words can elicit enhanced skin conductance responses (SCRs), a major autonomic index of emotional arousal, in normal participants. Our second aim was to determine whether any autonomic activation related to affective value of words is independent from access of this value to consciousness. Thus, the presentation duration of masked aversive and neutral words was determined, for each participant, in such a way that (1) identification was precluded, (2) valence discrimination was at chance, as indicated by performance in a forced-choice two-alternative task and by confidence ratings of the responses, and (3) emotional and neutral words were not detected differentially. SCRs were recorded during masked and unmasked presentations of both types of word. SCRs elicited by unmasked words, and also by masked words, were of greater magnitude when the words were emotional than when they were neutral. Consequently, in normal participants, autonomic activation can be a discriminative marker of the affective dimension of unrecognised verbal material in the absence of conscious valence identification.

Keywords: Emotion; Valence; Words; Electrodermal activity; Autonomic nervous system; Consciousness; Masking

1. Introduction

Recently, many emotion theorists have emphasized the importance of unconscious, automatic appraisal of stimuli in emotion (e.g. Clore, 1994; Lazarus, 1995; Leventhal and Scherer, 1987; Robinson, 1998; Öhman and Mineka, 2001). Particularly, a growing body of evidence suggests that judgment of the affective relevance of a stimulus for the individual (especially its fear relevance) can be made without one being able to identify the precipitating stimulus.

In this context, a good deal of research has been devoted to evaluate how individuals react to aversive

* Corresponding author. Tel.: +33-3-20-43-69-29; fax: +33-3-20-43-46-02.
E-mail address: Henrique.Sequeira@univ-lille1.fr (C. Verpoort).

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stimuli even if these are not consciously identified. To this end, some studies have measured autonomic reactivity, a classical index of emotional arousal, to non-identified fearful pictures. Öhman and Soares (1994) showed that phobic participants, when compared with healthy participants, reacted with higher skin conductance responses (SCRs) to phobic pictures than to neutral ones even when all pictures were backwardly masked and could not be identified consciously. Furthermore, when non-phobic participants received mild electric shocks (or aversive noises) to unmasked pictures of snakes and spiders (Öhman and Soares, 1993, Soares and Öhman, 1993a,b) or angry faces (Esteves et al., 1994; Parra et al., 1997; Peper and Karcher, 2001), they later showed larger SCRs to aversively conditioned pictures than to non-conditioned ones when backwardly masked.

Results have been interpreted in terms of biologically prepared fear reactions (Seligman, 1971) and thus more likely to occur to pictorial stimuli. Indeed, considering the evolutionary importance of fearful situations that might disrupt behavioural adaptiveness (e.g. Tooby and Cosmides, 1990), unconscious detection of threat is usually thought to rely on a quick and crude analysis of the stimuli (LeDoux, 1990). In this view, the autonomic system could be activated by biologically significant stimuli, without a conscious evaluation of the meaning of the stimulus, through simple physical stimulus features related to threat (e.g. rapid stimulus onset or sinusoidal shapes related to snakes; Öhman and Mineka, 2001).

In these conditions, one can wonder whether non-biologically prepared aversive stimuli may elicit autonomic activation when they are not consciously identified. In particular, words, as visual stimuli, are not phylogenetically relevant to the same degree as fearful pictorial stimuli, and unconscious processing of lexical information cannot rely only on perceptual features but must rather include some analysis of symbolic meaning. As a consequence, it appears unlikely that masked visual presentations of emotionally laden words can elicit autonomic activation.

However, experimental data indicate that the emotional meaning of unrecognised words can have an impact on autonomic activation, at least in phobic participants. Indeed, Van den Hout et al. (2000) recently reported that phobic participants showed enhanced SCRs to phobia-related and general threat words than to neutral ones, under masked presentations. Note also that the emotional meaning of unrecognised words can influence the speed of valence evaluation of a subsequent clearly visible stimulus (Croizet, 1998; Greenwald et al., 1989), a lexical decision about it (Kemp-Wheeler and Hill, 1988, 1992) or its affective evaluation (De Houwer et al., 1997; Greenwald et al., 1996). Interestingly, several researchers have shown that individuals with specific phobias fear and avoid circumscribed situations and tend not to have elevated trait anxiety or co-morbid psychopathology (e.g. Brown et al., 1997). Thus, specific trait characteristics of phobic people may not be the cause of enhanced responsiveness to masked general threat words observed in Van den Hout et al.'s experiment. As a consequence, it can be hypothesized that non-phobic individuals might also reveal enhanced autonomic reactivity to unrecognised aversive words.

Even though the aforementioned studies highlight a dissociation between conscious recognition/identification and autonomic activation, there are several concerns related to their masking procedure. For example, in the study of Öhman and Soares (1994), the masking parameters (stimulus and mask duration, stimulus onset asynchrony) had been defined in a pilot study in which other fearful and non-fearful participants had to guess which of the four stimulus categories (snake, spider, mushroom, and flower) was presented under various masking conditions. The masking parameters used for autonomic recording resulted, in the pilot study, in chance performance of both groups in this four-alternative forced-choice task. Thus, differential autonomic activation was elicited without conscious identification of the stimuli. Regarding verbal material, Van den Hout et al. (2000) established whether participants could recognise the masked words by the use of a lexical decision task. Immediately after the masked presentations in which SCRs were recorded, each of the words used in the experiment proper, supplemented by the same number of non-words, were presented in the same masking conditions. Participants were invited to indicate for each of the trials whether a word or a non-word had been presented. The masking procedure was considered as precluding word identification since the average accuracy for this two-alternative forced-choice task did not differ from 50%. Thus, autonomic discrimination of the emotional content of the masked words also occurred in the absence of conscious recognition/identification of these stimuli.

However, preventing the recognition/identification of masked stimuli does not necessarily exclude some behavioural valence discrimination. Indeed, it has been shown that participants exposed to masked faces are able to perform better than chance if they are asked to choose between faces that express affectively inconsistent emotions (smiling and scowling), whereas at the same time they are unable to accurately discriminate between faces that do not differ in emotional polarity, even if they differ on other obvious dimensions, such as gender (Murphy and Zajonc, 1993). Considering that above-chance performance on forced-choice tests reflects conscious access to partial information (e.g. Holender, 1986), the processing of affective information seems to have an earlier access to consciousness than the processing of information that is not affective in nature (Murphy and Zajonc, 1993). Consistent with this idea, Öhman and Soares (1994) reported that evidence of emotional responding to masked stimuli was not limited to the autonomic system but was also evident in emotional ratings. Indeed, fearful participants also reported more negative affects when exposed to masked phobia-related stimuli compared with neutral ones. Moreover, in conditioning studies (e.g. Parra et al., 1997), when participants rated masked non-conditioned and conditioned pictures, they were more certain that they would get shocked when conditioned pictures were presented than when non-conditioned pictures were presented. In contrast, Peper and Karcher (2001) carefully determined individual masking parameters, defining stimulus identification as correct valence identification with the presence of the stimulus detected. Unawareness of the masked stimuli was thus defined as 50% correct responses on both valence identification *and* detection of stimulus occurrence. However, this duration was determined before the conditioning session and the authors did not assess whether masked presentation of previously conditioned pictures were rated differently from masked non-conditioned pictures in terms of valence (but see Wong et al., 1994) or of association with an aversive stimulus. Finally, Van den Hout et al. (2000) did not control whether the observed autonomic discrimination was associated with a verbal or behavioural discrimination of the three sets of words on the emotional dimension.

In summary, it cannot be definitively excluded that autonomic discrimination of unrecognised/unidentified stimuli was the result of the earlier access of affective information to consciousness. Indeed, none of these studies clearly indicated a dissociation between valence discrimination, as indexed by behavioural cues, and autonomic responding. Thus, it appears important to demonstrate that any autonomic activation related to affective value of words may be independent from any kind of access of this value to consciousness. One way to highlight such a dissociation would be the demonstration that, at a given presentation duration, participants who cannot discriminate the valence of words more often than expected by chance nonetheless exhibit differential autonomic activity in response to emotionally negative and neutral words. In the present study, presentation duration of masked aversive and neutral words was determined individually in such a way that, (1) identification was precluded, (2) valence discrimination was at chance, as indicated by performance in a forced-choice two-alternative task based explicitly on the affective dimension of the stimuli and by confidence ratings of the responses, and (3) emotional and neutral words were not detected differentially.

2. Materials and methods

2.1. Participants

Seventeen undergraduate female students, aged between 20 and 27 years, participated in this experiment. All of them had normal or corrected-to-normal visual acuity and stated that French was their first language.

2.2. Stimuli

Four- to seven-letter French words were used as stimuli. They were selected from a pool of 80 words among the 904 proposed by Messina et al. (1989) with a rating of their emotional valence. This pool was assessed by 62 female students, different from the participants of the present study but recruited from the same population of students. These 80 words were rated in terms of valence and arousal, the two primary dimensions of emotions (Lang et al., 1990; Russel, 1980), with the paper-and-pencil version of the Self-Assessment Manikin (SAM; Bradley and Lang, 1994) rating system. The nine-point scales ranged from *unpleasant* to *pleasant* (from 1 to 9) for the valence dimension and from *calm* to *excited* (from 1 to 9) for the arousal dimension. Students were also asked to rate the frequency at which they use or encounter those words on a nine-point visual analogue scale.

The final pool contained 30 items: 15 emotional words with a negative value (e.g. war, cancer, murder, etc.) and 15 neutral words (e.g. table, door, notebook, etc.). The difference in the mean rating between the two sets of items was significant for valence and arousal but not for frequency (see Table 1). A non-significant difference between the two sets of words was also obtained when the frequency scores provided by Brulex, a lexical database for French words (Content et al., 1990), were considered ($t(28) = 0.21$, ns).

From each pool of 15 words, 12 were used in the pre-experimental phase to determine the presentation duration of the masked words for the experimental phase. The 3 remaining words of each pool (suicide—*suicide* in French, tumour—*tumeur*, incest—*inceste*, door—*porte*, carton—*carton*, ink—*encre*) were used in the experimental phase. None of the experimental words differed significantly from the pool of pre-experimental words of the same category regarding valence, activation or frequency ratings (as assessed by *t*-tests comparing the ratings of each experimental word with the mean ratings of the pool of pre-experimental words of the same category).

All the stimuli were presented in the same spatial location in the centre of the computer screen, on a black background (0.013 cd/m^2). The words were written in uppercase grey (29.9 cd/m^2) letters (Arial font). The length of the words varied between 1.5° and 2.5° of visual angle and the height was 0.43° at a distance of about 80 cm. The fixation point was a grey "+" in the centre of the screen. The mask consisted in a row of grey #s occupying 2.9° × 0.43° of visual angle.

Table 1
Valence, arousal and frequency mean ratings (± S.D.) for the two sets of words, and *t*-test for each dimension

	Emotional words	Neutral words	*t*-tests
Valence	1.37 ± 0.21	5.05 ± 0.15	$t(28) = -54.72$, $p < 0.001$
Arousal	7.88 ± 0.32	4.86 ± 0.18	$t(28) = 32.25$, $p < 0.001$
Frequency	5.72 ± 1.06	5.37 ± 0.68	$t(28) = 1.07$, ns

2.3. Apparatus

The stimuli were presented on a 19-in. Iiyama Vision Master pro 451 monitor (170 Hz). A Pentium III (450 MHz) computer with a 3D Prophet II Ultra video card controlled, by means of our own software ("Tasnim"), the stimulus display and the timing of events.

Skin conductance was recorded by the constant-voltage method (0.5 V). Beckman Ag–AgCl electrodes (8 mm diameter of active area) filled with 0.05 M NaCl electrolyte were attached to the palmar side of the middle phalanges of the second and third fingers of the participants' nondominant hand by means of double-sided adhesive collars. Electrodes were connected to Coulbourn S71-23 isolated skin conductance couplers linked to a microcomputer whose software ("RED", developed in our laboratory) allowed visualization, storage and analysis of electrodermal activity (EDA).

2.4. Procedure

The experiment had two phases, pre-experimental and experimental, taking place on two different days of the same week. The aim of the pre-experimental phase was to determine, for each participant, the presentation duration of the masked words for the experimental phase in which EDA was recorded. Backward masking parameters were determined individually since the use of a single, fixed condition of presentation for all participants may result in a considerable error variance (Wong et al., 1994). Both phases were run in exactly the same conditions (same room, same equipment for stimulus presentation, same experimenter). Before each phase began, participants habituated to the luminosity of the room and screen for 10 min, while the experimenter explained the task and/or attached the electrodes. The pre-experimental phase lasted about 1 h 30 min and the experimental phase about 30 min. At the end of the experiment, participants were asked to rate the words that had been used, in terms of valence and arousal, with the SAM. This confirmed that the emotional words were considered more negative and arousing than the neutral ones ($t(16) = 14.83$, $p < 0.001$ and $t(16) = 7.29$, $p < 0.001$, respectively).

2.4.1. Pre-experimental phase: determination of the exposure duration of the masked words

Participants were exposed to several sequences of trials. Each trial was as follows: fixation point for 1 s; word for a variable duration as a function of the sequence; mask for 150 ms; black background until the next trial. Within each sequence, the exposure duration of the word remained constant. In the first sequence, this duration was of 11.8 ms (this is two cycles on a 170-Hz screen) and for the next sequences, duration was raised by steps of 5.882 ms (one cycle).

For each exposure duration, sequences contained 60 trials: 30 emotional words and 30 neutral words (each word appearing two or three times). Within a sequence, the order of presentation was random with the restriction that only two successive exposures of each stimulus type were allowed.

For each trial, participants answered three questions: "Did a word appear before the mask?" (present/absent question); "Was the word before the mask emotional or neutral?" (emotional/neutral question); and "Which word appeared before the mask?" (identification question). Participants were required to answer the emotional/neutral question even if they felt that no word was present before the mask. They were also told that, in each sequence, each type of word would be presented an equal number of times in random order and that "neutral" and "emotional" responses should be distributed as equally as possible. They were further asked to answer the identification question as soon as they could read a letter, even if guessing. In order to encourage guessing, participants rated their confidence in each answer on a nine-point scale ranging from "absolutely uncertain" to "absolutely confident". Answers were given orally and collected by the experimenter. Participants triggered each trial by pressing the letter "A" on the keyboard, so that they could have a break whenever they wanted. Rest periods were also included between sequences.

This phase ended when participants reached the criterion of at least 50% correct identifications of the neutral or emotional words. Thus, four participants stopped at 29.4 ms, eight at 35.3 ms, four at 41.2 ms and one at 47.1 ms.

The exposure duration of the words in the masked presentation session of the experimental phase was determined for each participant in such a way that, in the pre-experimental phase: (1) no identification occurred, (2) performance on the emotional/neutral question did not exceed 50% accuracy, (3) the confidence was not different for correct and incorrect responses (emotional/neutral question), and (4) emotional and neutral words were not detected differentially (present/absent question).

2.4.2. Experimental phase: EDA recording

The experiment included a masked presentation session followed by an unmasked presentation session (in which the mask was presented but was ineffective because of the longer word duration). The order of those sessions was not balanced because prior exposure to clearly visible words was suspected to result in less efficient masking in the second phase. Since the main interest of the experiment was to compare SCRs to emotional and neutral masked words, it was more interesting to ensure uniform masking effects than to provide unbiased comparisons between masked and unmasked presentations (see Öhman and Soares, 1994).

Participants sat at a table in front of the computer screen. The experimenter attached the electrodes, explaining that the experiment consisted of the recording of physiological reactions to different types of words. The participants were told that their task was to be very attentive to what happened on the screen, avoiding moving or talking.

Each of the two presentation sessions consisted of two presentations of each of the six selected words (three neutral and three negative words) in a pseudo-randomised order (only two successive exposures of each stimulus type were allowed), different for each participant. The pseudo-randomised order was conceived in such a way that the first word of a session was neutral for nine participants and emotional for eight participants, the second word was neutral for eight participants and emotional for nine participants, and so on. During the masked presentation session, the words were projected for the duration determined for each participant in the pre-experimental phase. During the unmasked presentation session, the words lasted 150 ms and were easily readable, as reported by all participants. In both cases, the fixation point remained on the screen between each trial and each word was immediately (null inter-stimulus interval) followed by a 150-ms exposure of the mask. In order to avoid to take into account a potential strong initial orienting reflex elicited by the mask (especially in the masked presentation session), the two sessions began by a trial without word, excluded from the analyses. An experimenter, blind to the stimulus content, started trials when the EDA was stable. Inter-trial intervals varied between 25 and 35 s, with a mean of 30 s. Thus, each session lasted about 6 min. EDA was continuously recorded, except during the 5-min rest period between the two sessions.

Immediately after the masked presentation session, participants were asked whether they had been able to read words before the masks. At the end of the experiment, participants were invited to rate each of the 30 words used in terms of valence and arousal with the SAM test.

Specific SCRs to words were measured in micro-Siemens and analysed offline. They were scored as changes in conductance starting in the 1–4 s interval after onset of the word (Dawson et al., 1990).

3. Results

3.1. Determination of the exposure duration of the masked words

First, the primary report of a word (correct or incorrect identification) occurred at 17.6 ms for eight participants, at 23.5 ms for four participants, at 29.4 ms for three participants, at 35.3 ms for one participant, and at 47.1 ms for one participant.

Second, an accuracy score for the emotional/neutral question was calculated for each participant and each sequence. The upper limit of the 95% confidence interval per participant was 37 correct responses. Three participants scored lower than the limit before 23.5 ms, nine before 29.4 ms, four before 35.3 ms and one before 47.1 ms. Thus, below those durations, participants performed no better than chance (i.e., 50% correct) when they were asked to discriminate the emotional value of the masked words. The same results were obtained when the upper limit of the 80% confidence interval per participant (35 correct responses) was considered. Moreover, the same results were also obtained when the accuracy score for the emotional/neutral question was calculated for the type of word corresponding to the most frequently used response (as a proportion of the number of responses for that type of words).

Third, for each sequence and each participant, we calculated the mean confidence scores for correct and incorrect responses to the emotional/neutral question. Two-tailed *t*-tests ($\alpha = 0.05$) indicated that those scores were not significantly different before 17.6 ms for one participant, before 23.5 ms for six participants, before 29.4 ms for four participants, before 35.3 ms for two participants, before 41.2 ms for one participant, and before 47.1 ms for one participant. At and above those durations, the confidence score was significantly higher for correct responses than for incorrect ones, except for two participants who never showed such a pattern of results (i.e., they never scored their correct responses as more confident than their incorrect responses). It is interesting to note that, for six participants, confidence scores were significantly higher for correct responses than for incorrect ones at presentation durations where accuracy for the emotional/neutral question was still at chance.

Regarding those results, presentation duration of the masked words for the experimental phase was set at 11.8 ms for eight participants, at 17.6 ms for four participants, at 23.5 ms for three participants, at 29.4 ms for one participant, and at 41.2 ms for one participant (see Table 2). At these levels, none of the participants (1) reported the identity of a word, (2) performed above chance at the two alternatives forced-choice task concerning the emotional value of the presented words, and (3) rated their correct responses for the emotional/neutral question as more confident than their incorrect responses.

We performed additional control analyses of the data from the experimental phase for the entire group at the chosen experimental durations. We tested the hypothesis that on the average the accuracy score for the emotional/neutral question was not significantly higher than 50%. The average accuracy was 48.9% ± 2.7% and this was not significantly different from 50% ($t(16) = 1.63$, ns). We also verified that the mean percentage of correct responses did not differ for neutral and emotional words (neutral words: 52.2% ± 9.7%; emotional words: 45.6% ± 7.3%; $t(16) = 1.79$, ns). Moreover, correct responses for the emotional/neutral

Table 2
Summary of the results (in ms) from the pre-experimental phase and individual presentation duration of the masked words for the experimental phase

Participants	Pre-experimental phase			Experimental phase
	Identification	Emotional/ neutral	Confidence	Exposure duration of the masked words
1	17.6	23.5	23.5	11.8
2	17.6	35.3	35.3	11.8
3	17.6	29.4	17.6	11.8
4	17.6	29.4	23.5	11.8
5	29.4	29.4	×	23.5
6	17.6	29.4	29.4	11.8
7	23.5	29.4	23.5	17.6
8	35.3	35.3	35.3	29.4
9	47.1	47.1	47.1	41.2
10	23.5	29.4	29.4	17.6
11	17.6	23.5	29.4	11.8
12	23.5	29.4	23.5	17.6
13	29.4	35.3	41.2	23.5
14	29.4	35.3	29.4	23.5
15	17.6	23.5	23.5	11.8
16	23.5	29.4	×	17.6
17	17.6	29.4	23.5	11.8

Identification: duration for which the first identification (correct or incorrect) of a word occurred. *Emotional/neutral*: duration for which the performance for the emotional/neutral question significantly differed from chance (more than 50% of correct responses). *Confidence*: duration for which mean confidence scores for correct and incorrect responses to the emotional/neutral question differed (×: for participants who never scored their correct responses as more confident than their incorrect responses).

question were not rated on average as more confident (3.66 ± 2.48) than incorrect responses (3.58 ± 2.44; $t(16) = 1.22$, ns). Thus, according to confidence ratings the participants felt that their responses reflected mere guessing. Also, at the chosen experimental durations, emotional words were not detected differentially from neutral ones (present/absent question). Four participants detected no words, two participants detected all the words, and chi^2 tests ($\alpha = 0.05$) for each of the other participants indicated that emotional words were never detected differentially from neutral ones. This was also true for the entire group: the percentage of detected emotional words (59.86%) did not significantly differ from the percentage of detected neutral words (56.4%; $t(16) = 1.62$, ns). Moreover, the length of the experimental words (five, six or seven letters) did not influence the performance on the present/absent question at the chosen experimental durations ($F(2,32) = 0.81$, Greenhouse–Geisser $\varepsilon = 0.72$, ns). Finally, performance on the present/absent question did not correlate with SCRs during masked presentation in the experimental phase: emotional words, $r = 0.007$; neutral words, $r = 0.005$.

3.2. SCRs

SCRs were square root transformed to normalize the data (Edelberg, 1972). Then, SCRs were averaged for each type of word and submitted to a 2×2 ANOVA including Word Category (emotional/neutral) and Mode of Presentation (masked/unmasked) as within-participant variables. The main effect of the Word Category was significant ($F(1,16) = 7.174$; $p < 0.05$), indicating that SCRs to emotional words were of greater overall magnitude than SCRs to neutral words (see Fig. 1). The main effect of Mode of Presentation was not significant ($F(1,16) = 0.372$, ns). The Word Category × Mode of Presentation interaction also failed to reach significance ($F(1, 16) = 0.229$, ns). Thus, the difference in SCR magni-

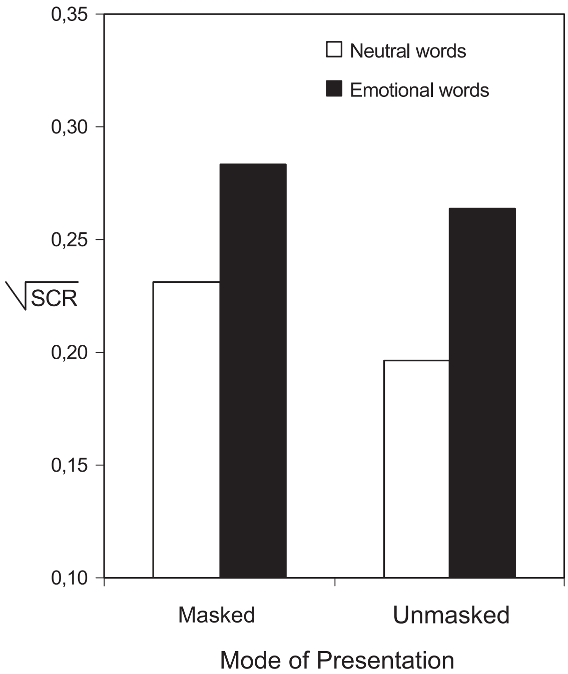

Fig. 1. Mean $\sqrt{\text{SCRs}}$ to neutral and emotional words in the masked and unmasked modes of presentation.

tude between emotional and neutral words observed under masked and unmasked conditions did not differ significantly. Pair-wise comparisons were nevertheless made with *t*-tests for each presentation mode separately. The difference between the two word-conditions was significant ($t(16)=2.68$; $p<0.05$) under masked presentations, but only marginally significant under unmasked presentation ($t(16)=2.01$; $p=.06$). If, in line with the hypotheses, one-tailed *t*-tests were used, the difference between emotional and neutral words reached significance in both modes of presentation (masked: $p<0.01$; unmasked: $p<0.05$). The same pattern of results was obtained with non-transformed data.

4. Discussion

The present study indicates that autonomic activation may discriminate between aversive and neutral masked words in normal participants. Such discrimination was established for words presented at a duration for which (1) identification was precluded, (2) valence discrimination was at chance, as indicated by performance in a forced-choice two-alternative task and by confidence ratings of the responses, and (3) emotional and neutral words were not detected differentially. Indeed, as for the unmasked condition, SCRs in the masked mode of presentation were of greater overall magnitude for emotional words than for neutral words. Hence, this study demonstrates that, in normal participants, masked verbal material is autonomically discriminated in the absence of stimulus identification and of conscious valence discrimination.

These results are reinforced by the methodology used to determine the presentation duration of the masked words. First, this duration was established individually, which appears crucial in this kind of experiment, regarding the important variability of thresholds we observed. Second, all conscious factors that seem relevant to the production of differential SCRs were carefully taken into account (identification was precluded, valence discrimination was at chance and detection performance did not differ between emotional and neutral words).

This work established that, like aversive and neutral masked pictures, negative and neutral unrecognised verbal stimuli can elicit discriminative autonomic activation. Several authors acknowledge that the processing of word valence may occur without conscious identification of these stimuli (see Robinson, 1998). Indeed, a growing body of evidence suggests that emotional significance of unrecognised verbal stimuli can, in normal participants, influence behavioural responses such as speed of valence evaluation (Croizet, 1998; Greenwald et al., 1989), lexical decision (Kemp-Wheeler and Hill, 1988, 1992) or affective evaluation (De Houwer et al., 1997; Greenwald et al., 1996) of a clearly visible stimulus. Extensive studies also report pre-attentive processing bias (automatic focusing of selective attention) for unrecognised threatening words in anxious individuals (see Mogg and Bradley, 1999 for a review). However, it remained unclear whether processing of the affective value of unrecognised words is associated with autonomic responding.

Following Van den Hout et al. (2000) study with phobic participants, the present results indicate that autonomic discrimination between emotionally negative and neutral words can occur for unrecognised words in normal participants. According to Öhman (1993) model (see also Öhman and Mineka, 2001), autonomic activation may be elicited by unrecognised biologically significant stimuli (through simple physical stimulus features related to threat) or by conscious identification of threat, through the evaluation of the meaning of the stimuli. This means that, while the significance evaluation does not require conscious identification of the stimulus (as shown in the aforementioned studies with words), such an evaluation can induce autonomic activation only through conscious identification of the stimulus. In contrast with Öhman's proposal, our results, in line with the study of Van den Hout et al. (2000), suggest that backward masking, which precludes word identification, does not prevents differential autonomic activation. This implies that the autonomic system can also be differentially activated by unrecognised emotionally negative and neutral words, that is by stimuli that are not biologically prepared and do not present simple physical features related to fear, but represent threat in a verbal manner.

The present results do not necessarily imply a full and detailed semantic analysis. Indeed, semantic processing (affective or not) of unrecognised words is usually thought to be relatively global (Pratto, 1994, Murphy and Zajonc, 1993; Mogg and Bradley, 1999), and more detailed analysis, such as evaluating relevance to specific self-relevant concerns, would necessitate full identification of the stimuli. A global level of semantic analysis, e.g. along a positive–negative dimension, may have been sufficient for autonomic activation to occur. This proposal is consistent with the observation that specific enhanced SCRs of phobic participants to phobia-related words were observed only with unmasked words (Van den Hout et al., 2001) whereas, with masked presentations, general threat words appeared as efficient as phobia-related words for inducing increased autonomic activity.

Another important aspect of the present results is that autonomic discrimination occurred in the absence of stimulus identification *and* of conscious valence discrimination. This may have not been the case in the Öhman and Soares (1994) study, where participants showed a small but reliable differentiation in emotional ratings of masked pictures, nor in the Parra et al. (1997) study, where participants rated the masked non-conditioned pictures higher in liking and less likely to be followed by a shock than the masked conditioned pictures. As Öhman and Soares (1994) acknowledged, these results suggested that some information about the pictures were consciously accessible or, in other words, ''that some information about the stimuli became available to introspection and the verbal-cognitive system'' but that ''this information did not influence the conscious perceptual identification of the stimuli because it was not reflected in recognition performance'' (p. 238). Öhman and Soares (1994) and Parra et al. (1997) proposed that participants could have used information generated by the autonomic response to guide their affective or shock expectancy ratings. This interpretation fits well with the James–Lange theory of emotion (James, 1884) and with more recent neuropsychological accounts of emotion (e.g. Damasio, 1994). In line with this idea, Katkin et al. (2001) recently studied fear-conditioned participants with masked pictures of spiders and snakes, excluding participants who performed better than chance in a forced-choice recognition task. If an image was followed by a shock, the shock came 5.6 s after the mask. During this delay, participants were asked to predict on each trial whether or not they would receive a shock. The authors showed that, although they could not recognise masked pictures, participants who were more sensitive to their own visceral activity, as indexed by their ability to detect heartbeats, predicted shock occurrence better than participants who were insensitive to their visceral activity. However, as acknowledged by the authors, these results do not prove causality. Thus, it cannot be definitively excluded that, in their studies, the affective verbal discrimination or the differential shock expectancy was sustained by some relevant information about the valence of the pictures that were consciously accessible despite masking. In this case, autonomic discrimination could have resulted from this prior conscious valence discrimination. On the contrary, the present results clearly indicate that differential autonomic reactivity can be dissociated from conscious valence discrimination.

Finally, one can question whether the autonomic discrimination observed in the masked condition of the present study reflects attention or emotion. Indeed, SCRs are known to reflect the activation of an emotional response but also the attentional switch associated with an orienting reflex (e.g. Boucsein, 1992; Öhman, 1979). In the present study, emotionally negative masked words elicited stronger SCRs than neutral words, despite the fact that they were unrecognised and that valence discrimination was at chance. Thus, it seems that masked presentations of negative words were not accompanied by a subjective emotional experience, usually thought to be the emotion defining feature (e.g. Frijda, 1999; Clore, 1994). It may be that only a primary component of the emotional response was activated by the masked stimuli: an initial orienting reflex, the function of which is to allow fast perceptual judgments and actions. In a general manner, such a pre-attentive detection of emotional stimuli, especially arousing negative ones, makes good evolutionary sense due to its survival implications. Pre-attentive mechanisms would ensure a rapid focusing of attention and privileged entry of the stimulus into consciousness. This could subsequently offer a head start toward greater allocation of cognitive capacity to deal with the ongoing emotional situation, which may be of particular relevance in emergency situations (e.g. Robinson, 1998). The present results suggest that these properties could also be devoted to the processing of negative words, which only represent threat in a verbal way and are thus weaker predictors of danger, and usually rated as less aversive than pictures (e.g. Kindt and Brosschot, 1997). It may be that a crude stimulus analysis is sufficient to determine whether a pictorial or verbal stimulus contains potentially negative information, but that further semantic analysis is necessary to achieve an accurate judgement of the situation and to discern different degrees of threat.

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