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ORIGINAL ARTICLE

Psychophysiological reactivity to symptom-related emotional stimuli in insomnia: A replication and extension to disordered eating

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Abstract

The present study examined psychophysiological reactivity to emotional stimuli in people with persistent insomnia alone or comorbid with disordered eating and in healthy controls. Female participants (39) were presented with 5 blocks of stimuli differing for valence (positive, negative or neutral) and for relatedness to the symptoms complied (sleep or food and body shape). Facial EMG over the corrugator and the zygomatic muscles, Heart Rate, Skin Conductance Level and subjective ratings of valence and arousal were recorded. Results confirmed that people complaining of symptoms of persistent insomnia show reduced activation of the corrugator muscle when exposed to positive stimuli related to sleep. This effect, interpreted as craving, was also found in the asymptomatic control group for the stimuli depicting fit bodies or healthy foods. An enhancement of the corrugator activity indicative of a worry effect was found in the healthy control group for negative sleep related stimuli and in the group with a mixed symptomatology for the negative stimuli related to food and body shape.

Key words: insomnia, disordered eating, emotions, facial EMG.

INTRODUCTION

Most etiological theories explain insomnia as due to the enhanced activity of the arousal system[1] or to the deficit of the de-arousal system.[2] Available evidence[1,3,4] demonstrates that people with insomnia as compared to control groups show heightened cortical and peripheral arousal levels, higher metabolic rates and higher cognitive and emotional activation. As regards the role of emotions in insomnia, most empirical studies have considered the role of negative emotions[5–7] and only few have addressed the influence of positive emotions. However, a recent review[4] failed to find a systematic relationship between sleep quality and positive emotions.

To this issue we wanted to replicate a previous study[8] aimed at evaluating psychophysiological responses of people with insomnia to stimuli characterized by different valence (positive, negative, neutral) and related or not related to sleep. Results evidenced that people with insomnia exhibit greater inhibition of the corrugator activity in response to sleep-related positive stimuli compared to the other kind of stimuli.

However, in the previous study, besides the effect interpreted as craving, the worry effect suggested by

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another researcher[5] was not found. Since only stimuli with low levels of arousal were included in that study, it is possible to hypothesize that high level of arousal are needed, as suggested by Cacioppo and Gardner.[9] According to these authors the motivation to approach is stronger than the motivation to avoid at low levels of evaluative activation (positive offset or positivity bias), while at high level of arousal a tendency to show enhanced responses to negative stimuli than to positive is present (negativity bias).

The second reason we replicated the study is that in the previous one, in order to control for variables that could spuriously influence results, people high in anxiety and depression were excluded. These selection criteria, while increasing internal validity, could limit generalizability, since it is well recognized that insomnia is frequently associated with heightened levels of depressive mood and anxiety and the comorbidity between insomnia and anxiety or depression is very high.[10] Thus we wanted to assess whether the craving effect could be found also in people not selected for having low levels of depression or anxiety. Furthermore, psychophysiological and subjective responses of people with insomnia were compared to those of people who show also another clinical condition, namely high symptoms of disordered eating. We decided to compare emotional responses of people with insomnia and people with eating disorders for the following reasons. Both the sleep/wake cycle and feeding behavior are regulated through the hypocretinergic/orexinergic neurons of the lateral hypothalamic area (LHA) that influence both the switch involved in the sleep/wake cycle and feeding behavior.[11,12] Furthermore, orexin neurons are also related to affective processes, since efferent pathways from the amygdala to the LHA orexin neurons have been evidenced and orexin production has been demonstrated to be activated by emotional events.[13] Thus, the frequent experience of negative emotions, due to difficulties in regulating them, could disrupt both poor sleep and eating behavior. Furthermore, since the affective system could influence the arousal and feeding systems driving attention on relevant stimuli, it is plausible to hypothesize that both systems, and both disorders as a consequence, show similar patterns of responses to relevant emotional stimuli.

Aims

The aim of the present study was to evaluate whether groups selected on the basis of their self-referred symptoms (symptoms of insomnia, symptoms of disordered eating, no insomnia or disordered eating symptoms) show different psychophysiological responses to emotional stimuli related and non-related to their symptoms.

METHOD

Participants

Four hundred and sixty-two females were approached around the university sites. Three hundred and twenty-seven signed the consent form for participating in the laboratory session and filled in the questionnaires. All participants were students of Sapienza University of Rome and most (n = 318) were psychology students. Thirty-nine participants eligible according to the criteria described below (mean age 24.77; sd = 3.8) were physiologically recorded.

Screening measures

The questionnaires used for the screening were:

1 A schedule for the collection of socio-demographic data.

2 Measures of insomnia symptoms:

- **a** Sleep Disorder Questionnaire (SDQ):[14] a brief self-report questionnaire which evaluates the presence of insomnia based on the combined criteria indicated by the DSM-IV, the ICSD-2 and consensus reports.[15] According to these criteria, syndromal chronic insomnia could be hypothesized when symptoms are described as chronic for at least one month and frequent for at least three nights per week, and when clinically relevant daily consequences (e.g., decreased functioning at work and/or in social and personal life) are reported. The questionnaire allows classification of respondents into three classes: (i) good sleep (GS): people who report no sleep problem; (ii) persistent insomnia (PI): people who report clinically significant symptoms of chronic insomnia consistent with the diagnostic criteria previously described; and (iii) subthreshold insomnia (SI): people who report symptoms of insomnia with weekly frequency, persistence or consequences lower than those indicated by diagnostic criteria.
- **b** Insomnia Severity Index (ISI):[16] a scale which assesses the severity of insomnia with respect to its influence on diurnal efficiency and wellbeing. Scores higher than 7 indicate the presence of clinically relevant insomnia symptoms (subthreshold, moderate severity, severe).

3 Measures of disordered eating symptoms:
   - **a** Disordered Eating Questionnaire (DEQ):[17] a 24-item questionnaire assessing the presence and intensity of eating disorder symptoms according to the DSM-IV-TR diagnostic criteria and with a time frame of 3 months. It includes 18 items asking people to indicate on a 6-point frequency scale the frequency of disordered eating and purging behaviors; 6 items which measure, through a 7-point Likert-type scale, the severity of worries and intrusive thoughts related to weight, body shape, food, and calories. A total score is computed summing up all items except those assessing purging behaviors. A cut-off score of 30 provides a sensitivity of 83% and a specificity of 66%, comparable to and sometimes even bigger than other similar questionnaires.[18] The questionnaire also allows us to obtain information about weight and height for estimating the BMI with an accuracy of 95%.[18]
   - **b** Eating Attitude Test (EAT-26;[19] Italian version):[20] a 26-item questionnaire for the self-evaluation of symptoms commonly linked to anorexia or bulimia. Answers are given on a 4-point frequency scale (3 = always, 2 = usually, 1 = often, 0 = sometimes/rarely/never). A total score higher than 10 indicates a medium- to high probability of the presence of an eating disorder.

4 Other measures:
   - **a** State-Trait Anxiety Inventory, trait form (STAI[21] Italian version included in the Cognitive Behavioral Assessment Battery 2.0):[22] a questionnaire including 20 items; respondents are asked to rate how they generally feel on a 5-point Likert scale ranging from 1 (almost never) to 4 (very much so).
   - **b** Depression Questionnaire (DQ, included in the Cognitive Behavioral Assessment Battery 2.0):[22] a 24-item questionnaire measuring the intensity of depressive states. Respondents have to choose a Yes/No response for indicating if each item describes her/his current experience.

The protocol needed around 40 min to be filled in. Order of questionnaires was counterbalanced across participants.

Selection criteria

Participants were selected according to the following criteria:

1 Persistent insomnia group (PI): people classified as PI on the SDQ, reporting scores higher than 7 on the ISI, lower than 10 on the EAT-26, lower than 30 on the DEQ and a BMI in the normal range.
2 Group with both persistent insomnia and disordered eating symptoms (PI/DE): people classified as PI on the SDQ, scoring higher than 7 on the ISI, higher than 10 on the EAT-26, higher than 30 on the DEQ and with a BMI outside the normal range (either underweight or overweight).
3 Self-referred healthy asymptomatic control group (AC): people with BMI in the normal range and scoring lower than the cut-offs on either symptomatic questionnaires.

Scores on the depression and anxiety questionnaires were used for statistical control.

Procedure

Participants received detailed instructions and had electrodes attached.

A portable device, Psycholab VD13 (Satem), was used for acquiring psychophysiological data. Facial EMG activity over the corrugator and the zygomatic muscles was recorded using 6 mm surface silver-silver chloride electrodes placed following the "Guidelines for Human Electromyographic Research"[23] and attached with a liquid conductive gel (FIAB G005). Consistent with previous evidence,[24] electrodes were placed on the left side of the face. Heart rate (HR) was acquired as estimate based on inter-beat intervals. Disposable electrodes were placed on the internal surface of the wrists and attached through a self-adhesive solid gel. Skin conductance level (SCL) was recorded through 1 cm^2 golden electrodes placed on the forefinger and on the middle finger of the non-dominant hand.

The Psycholab VD13 was interfaced online with a PC and synchronized with the images presentation. The software Psycholab PC Soft (Series S) was used for reading and scoring the data with a sampling frequency of 10 Hz. A biocalibration was provided to check the recordings.

Participants were asked to sit on a chair in front of a computer monitor positioned at a distance of 60 cm. The size of the screen was 15.4″. The chair was adjusted in order to have the center of the screen at the level of the participant's eyes.

Five blocks of visual stimuli were presented: neutral (NT), positive related to food and body shape (P-F/S), negative related to food and body shape (N-F/S), positive related to sleep (P-S) and negative related to sleep (N-S). Blocks were counterbalanced across participants according to a Latin square distribution.

At the beginning of the first trial, two neutral stimuli were presented for familiarizing participants with the task. Responses recorded to these stimuli were not used for data analyses.

The blocks of visual stimuli were separated by about 1 min break. During the breaks, participants rated the emotional valence (pleasant vs unpleasant) and arousal (calm vs excited) of each block on the Self-Assessment Manikin (SAM),[25] a non-verbal pictorial assessment technique measuring the dimensions of valence and arousal on two continuous 9-point scales.

Participants were instructed to keep their heads still while watching the stimuli. A qualified psychologist and an advanced undergraduate psychology student conducted the experiment. Each participant received 6 euros at the end of the session.

Picture stimuli

Stimuli were 52:

- 2 initial neutral stimuli;
- 10 neutral stimuli (NT) including picture of objects and people with neutral expressions;
- 20 sleep-related stimuli: 10 positive (P-S) including picture related to good sleep and 10 negative (N-S) including picture related to bad sleep.
- 20 food- or body shape–related stimuli: 10 positive (P-F/S) including body shape fit and thin or healthy food images and 10 negative (N-F/S) including body shape (too thin/anorexic or too fat/obese) or hyper caloric taboo food stimuli.

Neutral stimuli were selected from the International Affective Picture System (IAPS),[26] a widely used collection of visual stimuli for inducing emotions in laboratory. It includes color photographs with a known valence and arousal evaluated through the Self-Assessment Manikin. All neutral selected stimuli had a valence ranging between 4 and 6.

Stimuli positive and negative related to sleep were validated and used in a previous study.[8]

Stimuli related to food and body shape were either selected from the IAPS (n 2030, n 2037, n 2362, n 2620, n 4250, n 7286, n 7291, n 7359, n 7360, n 9926) or obtained from the web (uncopyrighted images) and validated on an independent sample of 40 volunteer female students of psychology at Sapienza University of Rome, aged between 18 and 30 years (mean age = 23.9; sd = 4.08).

Stimuli were balanced with respect to complexity, brightness and contrast. All stimuli had arousal lower than 6, notwithstanding the content and the valence. Within each block, pictures were ordered from lowest to highest level of arousal for avoiding that habituation as the block progresses could reduce the amplitude of the response. Pictures were presented with Superlab, version 2.1 (Cedrus Corporation, San Pedro, CA).

The research was approved by the Ethics Committee of the Department of Psychology of Sapienza University of Rome.

Data preparation and analyses

1. Selected groups were compared using one-way ANOVAs with respect to age, anxiety, depressed mood, severity of insomnia symptoms, severity of eating-disorder symptoms and BMI.
2. As regards subjective measures, two mixed-design factorial ANOVAs GROUP × CONTENT were computed using the GROUP (PI vs AC vs PI/DE) as between-subjects factor, the CONTENT of the stimuli (neutral vs positive related to food and body shape vs negative related to food and body shape vs positive related to sleep vs negative related to sleep) as within-subjects factor, and respectively the subjective ratings of VALENCE and AROUSAL as dependent variables.
3. As regards the 4 psychophysiological measures, a mean was computed for each variable recorded during the 60 seconds before the beginning of the task, in order to have a baseline value. These 4 means were considered as dependent variables in four one-way ANCOVAs which used the GROUP as factor and the STAI as covariate. The 4 ANCOVAs were repeated using the DQ scores as covariate.
4. As regards the psychophysiological data recorded during the emotional task, within each block, data were first checked for outliers, which were substituted by the mean of the condition. A value was considered outlier if ± 2sd of the mean of the condition. Based on the arousal levels of the stimuli, data were divided into low (the 5 pictures with the lowest arousal level) and high (the five pictures with the highest arousal level) and a mean was computed for each level of arousal of each condition. Mean psychophysiological data were analyzed computing 8 mixed-design factorial ANCOVAs (4 ANCOVAs for the 4 variables recorded at low and 4 for those recorded at high level of AROUSAL of the stimuli) using the GROUP as between subjects factor and the CONTENT of the stimuli as within-subject factor. All 8 analyses were conducted considering STAI scores as covariate and then repeated considering the DQ scores as covariate.

Table 1 Descriptive data (mean ± sd) of the samples and differences across groups

	AC	PI	PI/DE		
	Mean ± SD	Mean ± SD	Mean ± SD	$F_{(df)}$	*P*
Age	23.62 ± 2.76	26.70 ± 5.02	24.00 ± 2.82	$2.68_{(2,36)}$	0.082
BMI	20.58 ± 1.60	21.42 ± 1.37	22.35 ± 4.07	$1.47_{(2,36)}$	0.243
Circadian preference (MEQ)	31.85 ± 6.71	31.92 ± 11.09	34 ± 9.46	$0.202_{(2,34)}$	0.818
Severity of insomnia (ISI)	2.23 ± 1.70	11.62 ± 2.81	13.31 ± 5.95	$30.07_{(2,36)}$	<0.001
Severity of disordered eating (DEQ)	8.33 ± 4.40	14.77 ± 7.20	56.54 ± 15.99	$81.76_{(2,36)}$	<0.001
Severity of disordered eating (EAT)	2.00 ± 2.31	2.38 ± 2.33	25.26 ± 12.91	$38.95_{(2,36)}$	<0.001
Trait anxiety (STAI-T)	35.46 ± 7.76	44.00 ± 9.62	55.31 ± 13.60	$11.43_{(2,36)}$	<0.001
Depression (DQ)	0.85 ± 1.14	5.31 ± 3.63	9.62 ± 4.80	$19.93_{(2,36)}$	<0.001

Differences among means and specific hypotheses were tested through LSD post-hoc tests alone (for main effects) or in combination with the test of simple effects (for interactions). The presence of the craving effect was tested comparing within each group the positive conditions to the other conditions. The presence of the worrying effect was tested comparing within each group the negative conditions to the other conditions.

Statistical analyses were conducted using SPSS 13.0.

RESULTS

Manipulation check: Differences between selected groups (PI vs PI/DE vs AC)

Means ± standard deviations and the Fisher (Fs) and probabilities (Ps) of the comparisons between groups are reported in Table 1. Groups do not differ for age and BMI. Both the PI and PI/DE groups show higher scores of insomnia severity than the AC group ($P < 0.001$) but do not differ from each other ($P = 0.552$). As regards the eating-disorder symptoms, the group PI/DE show higher scores than both the PI and AC groups on both questionnaires (ps < 0.001) while PI and AC do not differ from each other on both questionnaires (DEQ: $P = 0.302$; EAT: $P = 0.992$).

Regarding the level of trait anxiety, results indicate that the group PI/DE show higher scores than the PI ($P = 0.035$) and the AC groups ($P < 0.001$), while the PI and AC do not differ from each other ($P = 0.137$). The PI/DE group report also higher depression as compared to both the PI group ($P = 0.014$) and the AC group ($P < 0.001$); the last two also differ from each other ($P = 0.011$).

Manipulation check: Subjective evaluation of valence and arousal

Valence

Results evidence a significant main effect of the GROUP ($F_{(2,36)} = 4.60$; $P = 0.020$) and a main effect of the CONTENT ($F_{(4,144)} = 64.22$; $P < 0.001$). Post-hoc tests show that the PI/DE group rated as more unpleasant (4.94 ± 1.59) all types of stimuli, regardless of the emotional content, as compared to PI group (5.65 ± 1.54; $P = 0.046$) and AC group (5.95 ± 1.54; $P = 0.005$). AC and PI group do not differ from each other ($P = 0.376$). As regards the CONTENT, all groups rated positive stimuli, both related to sleep (7.82 ± 1.46) and related to food and body shape (6.97 ± 1.74) as more pleasant as compared to neutral (5.38 ± 1.27), negative related to sleep (4.07 ± 1.88) and food and body shape (3.30 ± 1.72) stimuli. Furthermore, positive sleep related stimuli were rated as more pleasant as compared to positive food and body shape related stimuli ($P = 0.012$) and negative food and body shape related stimuli were rated as more unpleasant respect to the negative sleep related stimuli ($P = 0.023$). The interaction GROUP × CONTENT was not significant ($F_{(8,144)} = 0.973$; $P = 0.460$).

Arousal

Results show a significant main effect of the CONTENT ($F_{(4,144)} = 11.91$; $P < 0.001$), Post-hoc tests evidencing that for all groups both negative stimuli were rated as more arousing (respectively food/body shape related: 4.66 ± 1.84; sleep related: 3.92 ± 1.58) than both positive (respectively 2.92 ± 1.88; 2.66 ± 1.99) and neutral stimuli (3.25 ± 1.69). Moreover negative

stimuli related to food and body shape were rated as more arousing than negative sleep related stimuli (P = 0.026). Positive stimuli related to sleep or to food and body shape do not differ from each other (P = 0.441). The interaction GROUP × CONTENT was not significant ($F_{(8,144)}$ = 1.40; P = 0.202).

Check of the baseline differences between groups (PI vs PI/DE vs AC)

No significant effect is present for baseline responses in any psychophysiological variable either considering the STAI scores (EMG corrugator muscle: $F_{(2,36)}$ = 0.123; P = 0.885; EMG zygomatic muscle: $F_{(2,35)}$ = 0.862; P = 0.431; SCL: $F_{(2,36)}$ = 0.519; P = 0.599; HR: $F_{(2,36)}$ = 0.443; P = 0.646) or considering the DQ scores as covariates (EMG corrugator muscle: $F_{(2,36)}$ = 0.173; P = 0.839; EMG zygomatic muscle: $F_{(2,35)}$ = 0.909; P = 0.412; SCL: $F_{(2,36)}$ = 0.620; P = 0.544; HR: $F_{(2,36)}$ = 1.463; P = 0.245).

Hypothesis testing: Psychophysiological measures

Zygomatic

The analyses evidence no significant effect.

Corrugator

Low level of arousal: If the STAI is considered as covariate, the analysis evidences a significant main effect for the CONTENT ($F_{(4,140)}$ = 2.99; P = 0.021, eta squared = 0.079; observed power = 0.786) and a marginally significant interaction GROUP by CONTENT ($F_{(8,140)}$ = 1.95; P = 0.057, partial eta-squared =0.100; observed power = 0.792). If the DQ is considered as covariate, the analysis evidences a significant main effect for the CONTENT ($F_{(4,140)}$ = 2.78; P = 0.029, eta squared = 0.233; observed power = 0.628) and a marginally significant interaction GROUP by CONTENT ($F_{(8,140)}$ = 1.69; P = 0.106, partial eta-squared =0.167; observed power = 0.675). In both analyses the covariates do not account for a significant portion of the variance.

Since the marginally significant effects could be due to the low power of the statistical tests, analyses of simple effects with LSD comparisons were conducted for testing the hypothesized differences. Results evidence that in the PI and PI/DE groups sleep positive stimuli induce greater inhibition of the corrugator muscle as compared to neutral stimuli (all ps < 0.016).

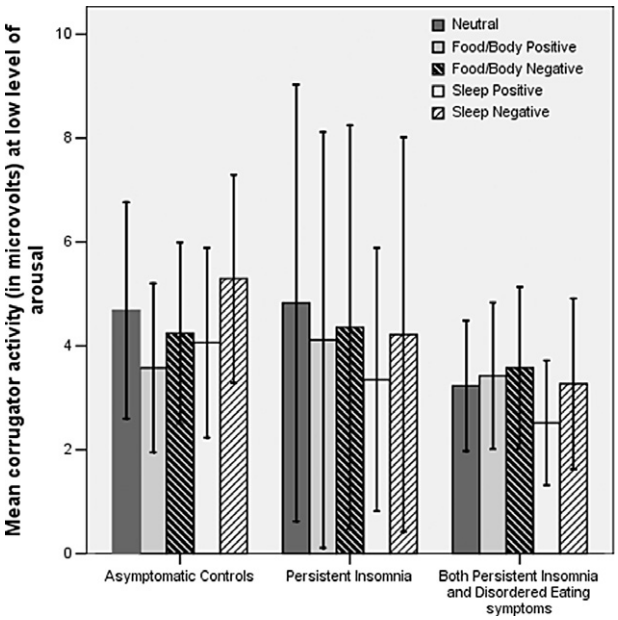

Figure 1 Changes in the corrugator muscle activity across groups and conditions, for stimuli with low levels of arousal. Error bars indicate standard errors.

Furthermore, in the AC group sleep negative stimuli induce greater activity of the corrugator muscle as compared to both the food and body shape positive and negative stimuli (ps < 0.006).

The means and the standard deviations across groups and conditions are reported in Figure 1.

The analyses conducted for the high level of arousal evidence a marginally significant effect for the CONTENT ($F_{(4,136)}$ = 1.95; P = 0.106) if the STAI is used as covariate and a significant main effect for the same factor ($F_{(4,136)}$ = 5.87; P < 0.001) when the DQ scores are considered as covariate. In both cases, LSD post hoc tests evidence that both positive stimuli reduce the activity of the corrugator muscle as compared to both neutral and negative stimuli (all P < 0.05).

The interaction GROUP by CONTENT is not significant both considering the STAI ($F_{(8,136)}$ = 1.00; P = 0.439) and the DQ scores ($F_{(8,136)}$ = 1.157; P = 0.330) as covariates. Since the non-significant interaction could depend on the low power (partial eta-squared = 0.064 and observed power = 0.520; partial eta-squared = 0.056 and observed power = 0.451 respectively for the first and the second interaction described), analyses of simple effects with LSD comparisons were conducted for testing only the hypothesized differences. Results evidence that in the PI group and in the PI/DE group

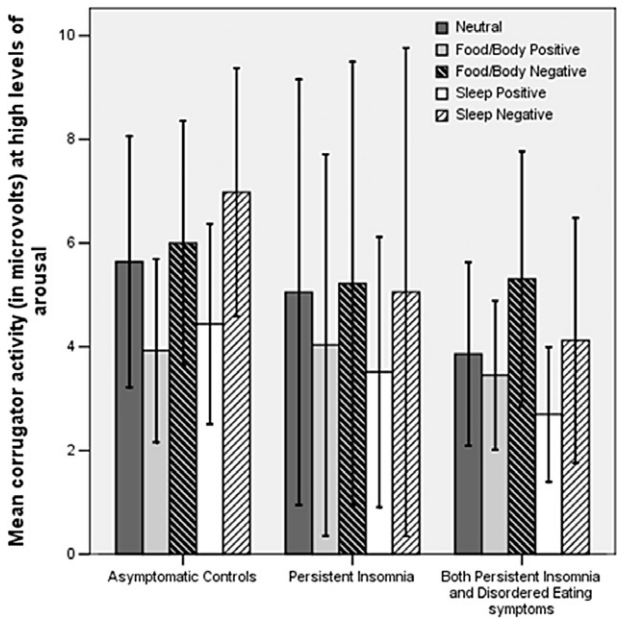

Figure 2 Changes in the corrugator muscle activity across groups and conditions, for stimuli with high levels of arousal. Error bars indicate standard errors.

sleep positive stimuli induce greater inhibition of the corrugator muscle as compared to neutral stimuli (all ps < 0.016); the enhancement of the corrugator muscle activity is evident again only in the AC group for sleep negative stimuli (all ps < 0.033).

The means and the standard deviations are reported in Figure 2.

In both analyses, the covariate does not account for a significant portion of the variance.

Skin conductance level (SCL)

Only a significant main effect for the factor CONTENT is present at both Low ($F_{(4,140)} = 3.169$; $P = 0.016$) and High ($F_{(4,140)} = 4.136$; $P = 0.026$) levels of arousal when anxiety is introduced as covariate. Post-Hoc tests show that food and body shape negative stimuli as compared to neutral stimuli induce greater skin conductance levels at both levels of arousal (both ps < 0.016). Means and standard deviation are reported in Figure 3.

No difference is present if the DQ is used as covariate.

Heart rate (HR)

The ANCOVAs comparing GROUPS and CONTENTs of the stimuli at the different levels of arousal and considering depression or anxiety as covariate, evidence no significant effect.

DISCUSSION

The main aim of the present study was to replicate results of a previous research[8] evidencing that people with insomnia show inhibition of the activity of the corrugator muscle when presented with sleep positive stimuli and to generalize them to conditions not analyzed in the previous study. To this issue people with persistent insomnia were compared not only to healthy controls but also to people complying of symptoms of insomnia comorbid with symptoms of eating disorders; positive and negative stimuli pertinent with this clinical condition were also added. Since the previous study used stimuli with low level of arousal, two groups of stimuli, one with low and one with high level of arousal were distinguished. Furthermore, participants were not excluded if scoring high on anxiety and depression measures but the effect of these variables was statistically controlled.

Results confirm that at both levels of arousal people complying of symptoms of persistent insomnia show reduced activation of the corrugator muscle when exposed to sleep related stimuli with a positive valence as compared to the neutral condition. Taken together, results of both studies are consistent with the idea proposed by Espie[2] that also positive emotional arousal could have disruptive effect on sleep.

A craving effect was also found in the asymptomatic control group but for stimuli related to fit bodies or healthy foods. Since all participants are females, they are sensitive to body shape or food stimuli characterized by a positive valence that are desirable conditions for healthy females, as reported by Davy *et al*.[27]

The craving for fit bodies and healthy foods was expected in people complying of persistent insomnia comorbid with disordered eating symptoms, who instead showed the craving effect only for the sleep related stimuli. The pattern of reposes observed in people within this group merits to be commented since they also show the worrying effect while observing stimuli related to food and body shape with negative valence at high level of arousal; moreover, as compared to the other groups, they evaluated as more negative all the stimuli presented, notwithstanding their valence and arousal and showed higher levels of depression and anxiety. These results may suggest that this group has a more severe clinical condition that, as a consequence, may have produced a lower reactivity of the facial mimicry to the emotional stimuli as suggested by several authors[28–30] or, at least, they needed high arousing stimuli for responding.

The worry effect was also found in the healthy controls for negative sleep related stimuli. This effect was

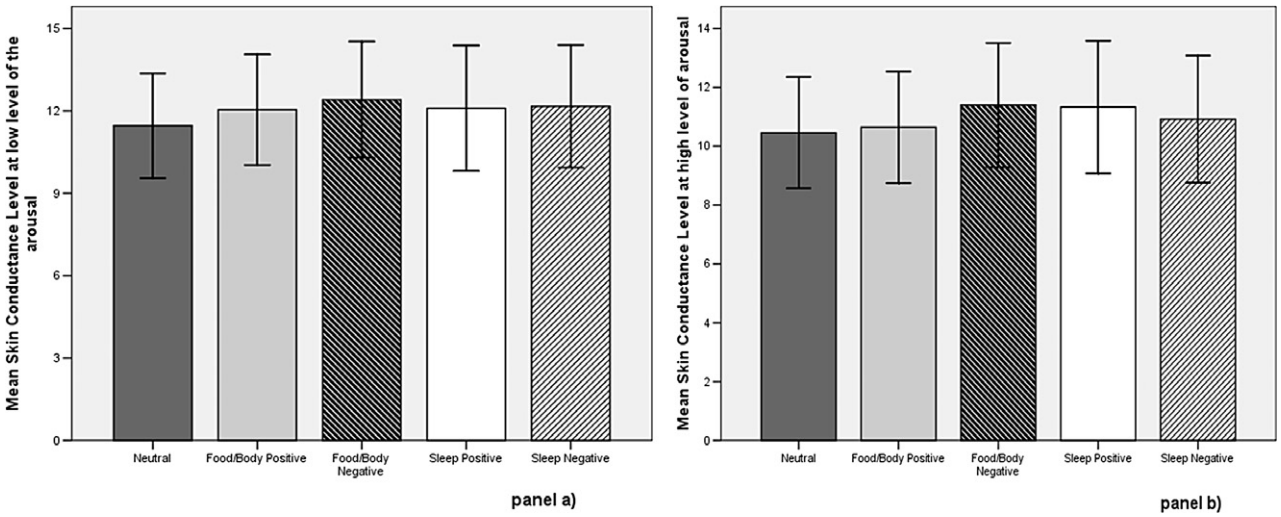

Figure 3 Changes in the skin conductance level across conditions at both Low (panel a) and High (panel b) levels of arousal. Error bars indicate standard errors.

not expected on the bases of the previous literature thus further studies are needed for confirming and evaluating its specific meaning.

As regards the SCL, higher values were recorded in the condition characterized by the highest level of arousal and the highest negative evaluation, namely negative stimuli related to food and body shape. This result may confirm that the SCL is an index of the negative arousal.

As regards the zygomatic muscle, no difference was found in the present research. This result seems inconsistent with the previous literature evidencing higher activation of this muscle in response to positive stimuli. However, this effect was probably not evident in the present study due to the small sample size.

Consistently with the previous study, no difference was found for the heart rate. Other authors, also failed to find these kind of differences[31] while differences have been reported when finer measures of cardiac responses (e.g. spectral analysis, CNV) are used.

Finally, as suggested by Cacioppo and Gardner,[9] we hypothesized that low level of arousal of the stimuli might produce a craving effect while high level of arousal might elicit a worrying effect. Results partially confirm this prediction since the craving is present at both levels of arousal. It is possible, however, that higher level of arousal than those used here are needed for inhibiting the approach response.

Before concluding, several limitations of the present study should also be acknowledged.

First, the study was conducted on groups defined on the bases of self-reported symptoms. However very strict criteria were used since for being selected people needed to have a specific BMI and to score in the clinical range on both questionnaires used for evaluating insomnia severity (the SDQ and the ISI) and disordered eating (the DEQ and the EAT-26). Furthermore, results of the manipulation check confirm that the groups selected are different both as regards the symptoms of interest and as regards the other clinical measures considered. For these reasons we are confident that the selection procedure, even if conducted only by means of self-reported data, was valid although it may have influenced the power of the statistical tests.

The second limitation is the low sample size that further reduced the statistical power of the analyses. On the bases of the previous study (5 conditions and 2 groups), it could be estimated that for having a power of 0.80, with an omega of 0.03, a sample size of at least 40 participants per group is needed. The procedure adopted here for selecting participants is very time and resource consuming since we obtained a sample size of 39 participants, who satisfied the strict criteria for inclusion, out of 462 (8% of the total sample) and thus we need a big sample (1500) screened for recording 120 participants. Due to this reason, we decided to communicate results of the present study although preliminary and to increase power in a future study conducted with patients.

REFERENCES

1 Riemann D, Spiegelhalder K, Feige B *et al*. The hyperarousal model of insomnia: a review of the concept and its evidence. *Sleep Med. Rev.* 2010; **14**: 19–31.

2 Espie CA. Insomnia: conceptual issues in the development, persistence, and treatment of sleep disorder in adults. *Annu. Rev. Psychol.* 2002; **53**: 215–43.
3 Bonnet MH, Arand DL. Hyperarousal and insomnia: state of the science. *Sleep Med. Rev.* 2010; **14**: 9–15.
4 Baglioni C, Spiegelhalder K, Lombardo C, Riemann D. Sleep and emotion: a focus on insomnia. *Sleep Med. Rev.* 2010; **14**: 227–38.
5 Harvey AG. A cognitive model of insomnia. *Clin. Psychol. Rev.* 2002; **40**: 869–93.
6 Kales A, Kales JD. *Evaluation and Treatment of Insomnia*. Oxford University Press: New York, 1984.
7 Morin CM. *Insomnia: Psychological Assessment and Management*. Guilford: New York, 1993.
8 Baglioni C, Lombardo C, Bux E *et al*. Psychophysiological reactivity to sleep-related emotional stimuli in primary insomnia. *Behav. Res. Ther.* 2010; **48**: 467–75.
9 Cacioppo JT, Gardner WL. Emotion. *Annu. Rev. Psychol.* 1999; **50**: 191–214.
10 Van Mill JP, Hoogndijk WJ, Vogelzangs N, Van Dyck R, Pennix BW. Insomnia and sleep duration in a large cohort of patients with major depressive disorder and anxiety disorders. *J. Clin. Psychiatry* 2001; **71**: 239–46.
11 Saper CB, Cano G, Scammell TE. Homeostatic, circadian, and emotional regulation of sleep. *J. Comp. Neurol.* 2005; **493**: 92–8.
12 Salin PR, Gerashchenco D, Greco M, Blanco Centurion C, Shiromani PJ. Hypotalamic regulation of sleep. *Neuropsychopharmacology* 2001; **25**: 21–7.
13 LeDoux J. The amygdale. *Curr. Biol.* 2007; **17**: 868–74.
14 Violani C, Devoto A, Lucidi F, Lombardo C, Russo PM. Validity of a short insomnia questionnaire: the SDQ. *Brain Res. Bull.* 2004; **63**: 415–20.
15 Lichstein KL, Durrence HH, Taylor DJ, Bush AJ, Riedel BW. Quantitative criteria for insomnia. *Behav. Res. Ther.* 2003; **41**: 427–45.
16 Bastièn CH, Vallieres A, Morin CM. Validation of the Insomnia severity Index as a clinical outcome measure for insomnia research. *Sleep Med.* 2001; **2**: 297–307.
17 Lombardo C, Russo PM, Lucidi F, Iani L, Violani C. Internal consistency, convergent validity and reliability of a brief Questionnaire on Disordered Eating (DEQ). *Eat. Weight Disord.* 2004; **9**: 91–8.
18 Lombardo C, Cuzzolaro M, Vetrone G, Mallia L, Violani C. Concurrent validity of the Disordered Eating Questionnaire (DEQ) with the Eating Disorder Examination (EDE) clinical interview in clinical and non clinical samples. *Eat. Weight Disord.* 2011; **16**: 188–98.
19 Garner DM, Olmested MP, Bohr Y, Garfinkel PE. The Eating Attitude Test: psychometric features and clinical correlates. *Psychol. Med.* 1982; **12**: 871–8.
20 Dotti A, Lazzari R. Validation and reliability of the Italian EAT-26. *Eat. Weight Disord.* 1998; **3**: 188–94.
21 Spielberger CD, Gorsuch RL, Lushene RE. *Manual for the State-trait Anxiety Inventory*. Consulting Psychologist Press: Palo Alto, CA, 1970.
22 Sanavio E, Bertolotti G, Michielin P, Vidotto G, Zotto AM. *CBA 2.0. Cognitive Behavioural Assessment. Scale Primarie*. Organizzazioni Speciali: Firenze, 1997.
23 Fridlund AJ, Cacioppo JT. Guidelines for human electromyographic research. *Psychophysiology* 1986; **23**: 567–89.
24 Blumenthal TD, Cuthbert BN, Filion DL, Hackley S, Lipp OV, van Boxtel A. Committee report: guidelines for human startle eyeblink electromypgraphic studies. *Psychophysiology* 2005; **42**: 1–15.
25 Bradley MM, Lang PJ. Measuring emotion: the self assessment manikin and the semantic differential. *J. Behav. Ther. Exp. Psychiatry* 1994; **25**: 49–59.
26 Lang PJ, Bradley MM, Cuthbert BN. *International Affective Picture System (IAPS): Affective Ratings of Pictures and Instructions Manual*. Technical report A-6, University of florida: Gainesville, FL, 2001.
27 Davy SR, Benes BA, Driskell JA. Sex differences in dieting trends, eating habits, and nutrition beliefs of a group of midwestern college students. *J. Am. Diet. Assoc.* 2006; **106**: 1673–7.
28 Jones N, Rogers PJ. Preoccupation, food, and failure: an investigation of cognitive performance deficits in dieters. *Int. J. Eat. Disord.* 2003; **33**: 185–92.
29 Meyer C, Leung N, Barry L, Feo D. Emotion and eating psychopathology: link with attitudes toward emotional expression among young women. *Int. J. Eat. Disord.* 2010; **43**: 187–9.
30 Rottenberg J, Gross JJ, Gotlib ICH. Emotion context insensitivity in major depressive disorder. *J. Abnorm. Psychol.* 2005; **114**: 627–39.
31 Leshner G, Bolls P, Wise K. Motivated processing of fear appeal and disgust images in televised anti-tobacco Ads. *J. Media Psychol.* 2011; **23**: 77–89.