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Treatment of chronic stress in employees: Subjective, cognitive and neural correlates

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This study reports the effect of an affect-focused intervention program, the Affect School, on stress, psychological symptoms, cognitive functioning and neural activity. Fifty employees in social service and education, with high levels of chronic stress, were randomly divided into a treatment ($N = 27$) and control ($N = 23$) group. Complete sets of data were available in 20 participants in the treatment group and 17 in the control group. The Perceived Stress Questionnaire assessed stress and the Symptom Check List-90 psychological symptoms before and after treatment. Episodic-memory functioning under focused and divided attention conditions was also assessed. Prior and after the Affect School, seven participants in the treatment group were studied with functional magnetic resonance imaging (fMRI) during episodic memory processing. After the Affect School there was a reduction in stress and psychological symptoms for the treatment group but not in the control group. The controls showed a reduction in episodic memory functioning whereas the performance of the treatment group remained intact. The fMRI scanning indicated a qualitative change in the neural network subserving episodic memory. These preliminary results suggest that the Affect School is effective on individuals with high stress.

Key words: Psychological stress, memory, emotions, intervention, functional imaging.

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INTRODUCTION

Chronic stress and long periods of sick leave increase in the modern society. Chronic stress arises from long-lasting threatening or harmful life conditions, mainly daily hassles at work and in private life (Lazarus, 1999). The stress reaction is a result of how a person interacts with the environment and can be regarded as a complex system of interacting psychological, physiological and environmental factors. Psychological stress arises when the relationship between the individual and the environment is appraised by the individual as causing situations that are taxing or exceeding his or her resources and endangering his or her well-being (Lazarus & Folkman, 1984). Two types of processes have been presented that mediate the person-environment relationship. First, cognitive appraisal, which is an evaluation process that determines whether or not the interaction between the individual and the environment is stressful, and second, coping, the process through which the individual handles the demands of an individual-environmental relationship that is appraised as stressful and the emotions that are induced. Psychological stress is associated with a variety of physical and mental symptoms such as anxiety, depression, sleep disturbances, irritability and psychomotor changes (Kenny, Carlson, McGuigan & Sheppard, 2000).

Stress and emotions are interdependent, that is, when there is stress there are also emotions. Stress, emotions and coping form a conceptual unit with emotion being the superordinate concept because it includes stress and coping. In stressful situations, the individual may be forced to use stereotypical psychological patterns in order to cope with activated negative affects such as worry, fear and anger. In such situations the risk that the individual becomes involved in dysfunctional relations increases, which can result in an elevated risk to develop chronic stress and associated symptoms.

Tomkins has presented an evolutionary-physiologically focused affect theory (Tomkins, 1962; 1963; 1991a; 1991b) that views affects as analogue amplifiers that create experiences of urgency. Affects are comprised of correlated sets of responses involving especially the musculo-skeletal, respiratory and autonomic nervous systems. The characterization of affects as an urgent, general and abstract amplifier is important in understanding the affect system, its motivational power and its central role in the stress reaction. Tomkins' affect theory includes eight specific primary affects: anger, disgust, distress, fear, interest, joy, shame and startle. Tomkins also presented the script theory; the scripts bring order to our experience by linking together sequences of affects

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and behavior that characterize significant and recurrent interactions. Dysfunctional scripts may influence the vulnerability to stress negatively, and challenging and restructuring these scripts can result in new, more functional, strategies to handle stressful situations.

A consequence of prolonged stress can also be impaired cognitive functioning. Hippocampal-dependent functions such as episodic memory have been found to be lowered in conditions of high stress, and such decrement correlate with a reduced hippocampal volume (Lupien *et al.*, 1998; Alderson & Novack, 2002).

A major question is whether heightened levels of stress and psychological symptoms such as anxiety and depression can be reduced by various intervention programs, and whether this affects cognitive functioning. This study reports the results of a manual-based structured affect-focused intervention program (Affect School) that was given to employees in areas where reports of high levels of stress is a frequent complaint. This particular intervention has been successful in a previous controlled study (Bergdahl, Armelius & Armelius, 2000) and when applied in primary care (Arnström-Johannessen *et al.* 2002). The overall goal of the Affect School is to increase the affect awareness, and the ability to perceive and express affects in order to improve the ability to cope with stress. The Affect School is based on Tomkins affect theory (Tomkins, 1962; 1963; 1991a; 1991b), in which each affect creates a distinctive qualitative experience about intrapsychic events and events in the environment.

In the present study, the hypotheses were that increased affect awareness improves the ability to cope with stress, which results in reduced stress symptoms and other related symptoms. This stress reduction facilitates cognitive functioning, which could be reflected in altered neural activity. Therefore, the aim of this study was to evaluate the effect of affect-focused intervention on psychological stress, psychological symptoms, cognitive functioning and neural activity. Neural activity was measured with functional magnetic resonance imaging (fMRI) before and after the intervention for a small subgroup of the treatment group. The main goal of this analysis was to examine whether a potential intervention effect affected the neural correlates of episodic memory processing.

METHOD

Participants

A total of 122 employees, 109 (89.3%) women (*M* age 42.8 yrs; range 20–62 yrs) and 13 (10.7%) men (*M* age 41.6 yrs; range 22–56 yrs), working in the areas of social service and education were initially included. By using a simple random assignment procedure, the participants were selected from lists of employees in social service, elderly care and school departments in a larger Swedish municipality. Of the 122 participants, 50 female employees (*M* age 41.4 yrs; range 20–62 yrs) with high stress level were selected for further testing and participation in the intervention that took place six months after the initial screening. They were randomly divided into a treatment ($N = 27$) and control group ($N = 23$). In order to compensate for possible dropouts during the intervention, the treatment group was slightly oversized. The treatment group was divided into four subgroups including 6–7 subjects each. A subset of seven participants in the treatment group was included in an fMRI study. The inclusion criteria was a high stress level at both the initial screening and the testing six months later, prior the intervention. The Ethics Committee for Human Experiments at Umeå University approved the study.

Instruments

Assessment of perceived stress. To measure general perceived stress the Perceived Stress Questionnaire (PSQ) was administered (Levenstein *et al.*, 1993). The PSQ emphasizes cognitive perceptions more than emotional states or specific life events and has been shown to be superior to alternative measures for predicting healthy outcomes. The PSQ is a 30-item questionnaire and the items are scored from 1 to 4. A PSQ-index, varying from 0 (lowest level of perceived stress) to 1 (highest level of perceived stress), is derived from the total raw score using the formula: (raw score – 30/90). A PSQ-index mean score of 0.22 has been reported in a Swedish population and cut-off scores for moderate levels of perceived stress were estimated to >0.34–≤0.46, and for high levels to >0.46 (Bergdahl & Bergdahl, 2002). The PSQ has been reported to have high validity and reliability (Levenstein *et al.*, 1993; Paul & Soon, 1993; Bergdahl & Bergdahl, 2002). The participants' ratings on the PSQ were compared with a Swedish normative group (Bergdahl & Bergdahl, 2002).

Assessment of psychological symptoms. The psychological symptoms were rated with the Symptom Check List-90 (SCL-90) (Derogathis & Cleary, 1977; Fridell, Cesarec, Johansson & Malling Andersen, 2002). The SCL-90 consists of 90 items, scored from 0 (not at all) to 4 (extremely) and grouped into nine different symptom dimensions: somatization, obsessive-compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation and psychoticism. The Global Severity Index (GSI), which is the mean of all 90 items, was used in this study to measure the level of psychological symptoms. GSI values over 1.0 typically reflect psychiatric conditions. A GSI of 0.50 has been reported as a normative value. The SCL-90 has high internal consistency and high test-retest reliability (Derogathis & Cleary, 1977; Fridell *et al.*, 2002). The participant's ratings on the SCL-90 were compared with a Swedish normative group (Fridell *et al.*, 2002).

Assessment of episodic-memory functioning. Fifty subjects with high scores on the PSQ and SCL-90 were selected for further testing that took place six months after the initial screening. All of these participants were given tests to evaluate their level of episodic-memory functioning. In one condition, twelve words were presented under focused attention conditions, and the task of the subjects was to memorize the words for a subsequent test of memory. In another condition, the attention was divided during the time of word encoding by means of a card-sorting task (Nilsson *et al.*, 1997). Both encoding conditions were immediately followed by tests of free recall (two minutes were allowed to recall as many words as possible in any order). Based on previous studies (Nyberg *et al.*, 1997) it was expected that division of attention during encoding would impair memory performance relative to the focused-attention condition. Swedish normative data were available from a large population-based study where this specific test is included (Nilsson *et al.*, 1997).

Affect-focused intervention

The treatment group ($N = 27$) participated in the Affect School, which is a group intervention program. Each group included 6–7

Table 1. *Session outline of the Affect School*

Session	General topic	Specific affect	Group discussion specific affect
1	Functioning of the affect system, script theory and stress. Definition of affects, feelings and emotions	Joy	Joy
2	Affects and the brain, scripts, stress	Fear	Fear
3	Scripts, stress	Interest, Startle	a. Interest b. Startle
4	Compass of shame, scripts, stress	Shame	Shame
5	Faces of affects, scripts, stress	Anger	Anger
6	Psychological smells, scripts, stress	Dissmell/disgust	Dissmell/disgust
7	Empathy, emotional intelligence, scripts, stress. Termination of treatment	Worry	Worry

participants and was led by two psychologists for seven weeks (one two-hour session per week) (Bergdahl *et al.*, 2000).

The Affect School derives from the eight specific primary affects described by Tomkins (1962; 1963; 1991a; 1991b). Each session of the Affect School lasted for 2 hours and consisted of three parts: a general topic, a specific affect and a group discussion of a specific affect (Table 1). In the first session, an introduction of the participants and leaders was given as well as a presentation of format, rules and goals of the intervention. Handouts for the sessions were distributed to the participants at the beginning of each session. The style of group leadership was characterized as educative, active and supportive. The sessions began with a 30-minute didactic presentation of topics related to affects and stressful situations such as the importance of the affect system, and the mechanism of stress reactions and affective scripts. Furthermore, in each session one or two specific affects were presented and the specific affect's role and importance was underlined and discussed. In the next step of the session, after a break, the participants were asked to remember and present a specific stress-related situation when they felt the actual affect, they also had to describe how this affect was experienced, how they expressed it verbally and non-verbally, and how they could identify other persons' expression of the specific affect (Bergdahl *et al.*, 2000).

The control group ($N = 23$) received equal attention before and after intervention as the treatment group. Complete sets of data before and after intervention were available in 20 participants in the treatment group and 17 in the control group (drop out = 7 & 6).

fMRI scanning. A subset of the participants in the treatment group ($N = 7$) was studied with fMRI before and after the intervention. The fMRI scanning involved an episodic face-name recognition test plus a baseline condition (Fig. 1). Of main interest was to see whether there were any changes in the activation patterns prior to compared with after the intervention. During encoding, subjects viewed faces with fictitious first person names underneath. They were instructed to memorize each face and name for a subsequent test and to press a response key in the right or left hand each time a new face was presented. At retrieval, the same faces were presented again (in a different order), but now marked with two names. The subjects were instructed to press the key (left or right) corresponding to the correct name for each face. The baseline task consisted of presentation of a red square in the centre of the screen. Letters (xxxxx or yyyyy) were randomly presented to the right or left below each square, and the task was to indicate the position of the x's by pressing a response key. In all conditions, ten items were presented at the rate of one item/3 sec. Each session (pre/post-intervention) included six experimental runs of the encoding-baseline-retrieval cycle.

The fMRI imaging procedures were as previously described (Elgh, Larsson, Eriksson & Nyberg, 2003). Specifically, magnetic resonance

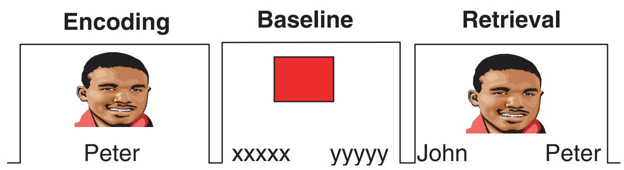

Fig. 1. Illustration of the fMRI protocol.

imaging was performed on a 1.5 T Philips Gyroscan ACS NT scanner (Philips Medical Systems, Netherlands) equipped for echo-planar imaging (EPI). For fMRI studies, a T2*-weighted single-shot gradient echo EPI sequence was used for blood oxygen level-dependent (BOLD) imaging. The following parameters were used: echo time: 50 ms, repetition time: 3,000 ms, flip angle: 90 degrees, field of view: 22 × 22 cm or 23 × 23 cm, 64 × 64 matrixes and 3.6 mm slice thickness. 36 slices were acquired every 3.0 seconds. Five "dummy scans" were performed prior to the image acquisition to eliminate signals arising from progressive saturation. The images were then sent to a PC and converted to Analyze format. High-resolution T1-weighted and T2-weighted structural images were acquired for each subject after the functional measurements.

Study design

Initially, 122 employees were randomly selected and the level of perceived stress (PSQ) and psychological symptoms (SCL-90) were assessed. In the next step, 50 employees with the highest scores on the PSQ were selected to participate in the intervention and were tested 6 months after the initial screening with the PSQ, SCL-90 and episodic-memory test. They were then randomized into a treatment and control group. The treatment group participated in the Affect School for 7 weeks. Within about 5 weeks after the intervention, the treatment and control group were retested with the PSQ, SCL-90 and episodic-memory test. Seven participants in the treatment group, who scored continuously high on the PSQ at both the initial and pre-treatment assessment, were studied with repeated fMRI scanning, within 5 weeks before and within 5 weeks after the intervention.

Statistical analysis

SPSS for Windows was used to compute independent *t*-tests for between-group comparisons and paired sample *t*-test for within-group comparisons of the PSQ, GSI on SCL-90 and episodic-memory test before and after intervention. An analysis of covariance (ANCOVA) was computed to analyze the interaction between PSQ and GSI scores and the treatment and control group. The ANCOVA was performed in order to adjust for the fact that much of the variability in post-treatment scores could be accounted for by variability in pre-treatment scores. As outcome measure for the PSQ, SCL-90, and the episodic-memory test, effect size values (ES) were computed (Rosenthal, 1991). The computation was performed so that positive value of ES indicated improvement and negative deterioration. The ES-values were interpreted according to Rosenthal (1991) where ES > ±0.20 indicate small, ES > ±0.50 moderate, and ES > ±0.80 large improvement/deterioration.

SPM99 (Wellcome Department of Cognitive Neurology, UK) was used for the fMRI analysis. The presented results are from two fixed effect ANOVAs: [(retrieval before – baseline before) – (retrieval after – baseline after)] and [(retrieval after – baseline after) – (retrieval before – baseline before)].

RESULTS

At the initial screening, the total employee group (N = 122) rated significantly higher (M = 0.36; SD = 0.14; $t(656)$ = 11.96, p < 0.001) than a sex- and age-matched normative group (Bergdahl & Bergdahl, 2002) on the PSQ (N = 536; M = 0.22; SD = 0.11), but equal regarding the GSI on SCL-90 (Fridell *et al.*, 2002) (Fig. 2a). The 37 participants with high levels of perceived stress (PSQ: M = 0.44; SD = 0.11) and psychological symptoms (GSI: M = 0.75; SD = 0.41) at the initial screening constituted the treatment (N = 20) and control (N = 17) group. They had continued high levels of perceived stress and psychological symptoms 6 months after the initial screening (PSQ: M = 0.45; SD = 0.11; GSI: M = 0.82; SD = 0.46; Fig. 2a).

There were no differences in the PSQ and GSI scores between the treatment and control group before the intervention. When the PSQ and GSI ratings of the treatment group were compared before versus after intervention, it was found that the employees reduced the PSQ scores significantly (M = 0.46; SD = 0.08 prior to intervention versus M = 0.37; SD = 0.13 after intervention; $t(19)$ = 2.94, p < 0.01). The GSI scores were also reduced significantly (M = 0.72; SD = 0.34 prior to intervention versus M = 0.57; SD = 0.27 after intervention; $t(19)$ = 2.26, p < 0.05) (Fig. 2a). This was not true for the employees in the control group (both p's > 0.10). The independent t-test showed no post-treatment differences in the PSQ and GSI scores between the treatment and control group. The ANCOVA, on the other hand, showed a significant GSI score/group interaction (B = 0.759; p = 0.03) and a tendency to a significant PSQ score/group interaction (B = 0.700; p = 0.110). The PSQ score/group and GSI score/group interactions are illustrated in Fig. 2b. The scatter plots and regression lines show that when the PSQ and GSI pre-treatment scores were higher, the differences of the post-treatment scores between the treatment and control group were larger.

It was furthermore found that the memory performance of both groups was normal relative to age-matched normative data during focused-attention conditions (Nilsson *et al.*, 1997). Under divided attention conditions, the memory performance of both groups was normal relative to age-matched normative data prior to the intervention (Nilsson *et al.*, 1997), and there were no between-group differences in memory performance. After the intervention, the performance of the treatment group remained at a normal level, whereas the performance of the control group was lowered relative to normative data as well as to the treatment group ($t(39)$ = 2.54, p < 0.05) (Fig. 3).

Effect-size values (ES) were used to measure post-treatment improvements in the treatment and control group on the PSQ, GSI, and performance on the episodic-memory test under focused- and divided-attention conditions. The computation was performed so that positive value of ES indicated improvement and negative deterioration. In the treatment group, there was large improvement on the PSQ (ES = 1.16) and a tendency to a moderate improvement on the GSI (ES = 0.47) (Table 2). In the control group, no improvement was seen on the PSQ and GSI, but moderate deterioration was observed on the episodic-memory test in the divided attention condition (ES = −0.66) (Table 2).

fMRI scanning

All of the participants who were included in the fMRI study had high stress levels at the initial screening (PSQ: M = 0.48), and also 6 months later, prior to the intervention (PSQ: M = 0.48). The level of stress was reduced after the intervention (PSQ: M = 0.36). A similar pattern was found regarding the level of psychological symptoms (SCL-90: M at initial screening = 0.74; M pre-intervention = 0.77; M post-intervention = 0.47). Consistent with the results from the memory testing, it was found that the level of recognition memory performance was the same before (M = 49.14, SD = 6.39) and after (M = 49.71, SD = 7.04) the intervention. The fMRI-encoding data revealed minimal differences in the activation patterns before versus after the intervention. In contrast, a pronounced difference was noted at retrieval. Prior to the intervention relatively increased activity was seen in the left prefrontal cortex, whereas after the intervention a region in the right prefrontal cortex showed relative increased activity (Fig. 4a). In both analyses, the frontal activations were the strongest (p < 0.001 corrected at voxel and cluster level).

We conducted additional analyses to examine whether the post-intervention reduction in left prefrontal activity reflected an effect of the intervention or a general time effect. For each of the six retrieval blocks in the pre- and post-intervention session, the percentage difference in signal intensity relative to baseline was computed based on data from the pre-processed fMRI image volumes. The voxel corresponding to the peak activity was chosen for the presentation. Scanner drifts were corrected by normalizing the average value of all image volumes to the same value. The results provided evidence that the reduction was tied to the intervention rather than to a general activity reduction over time (Fig. 4b).

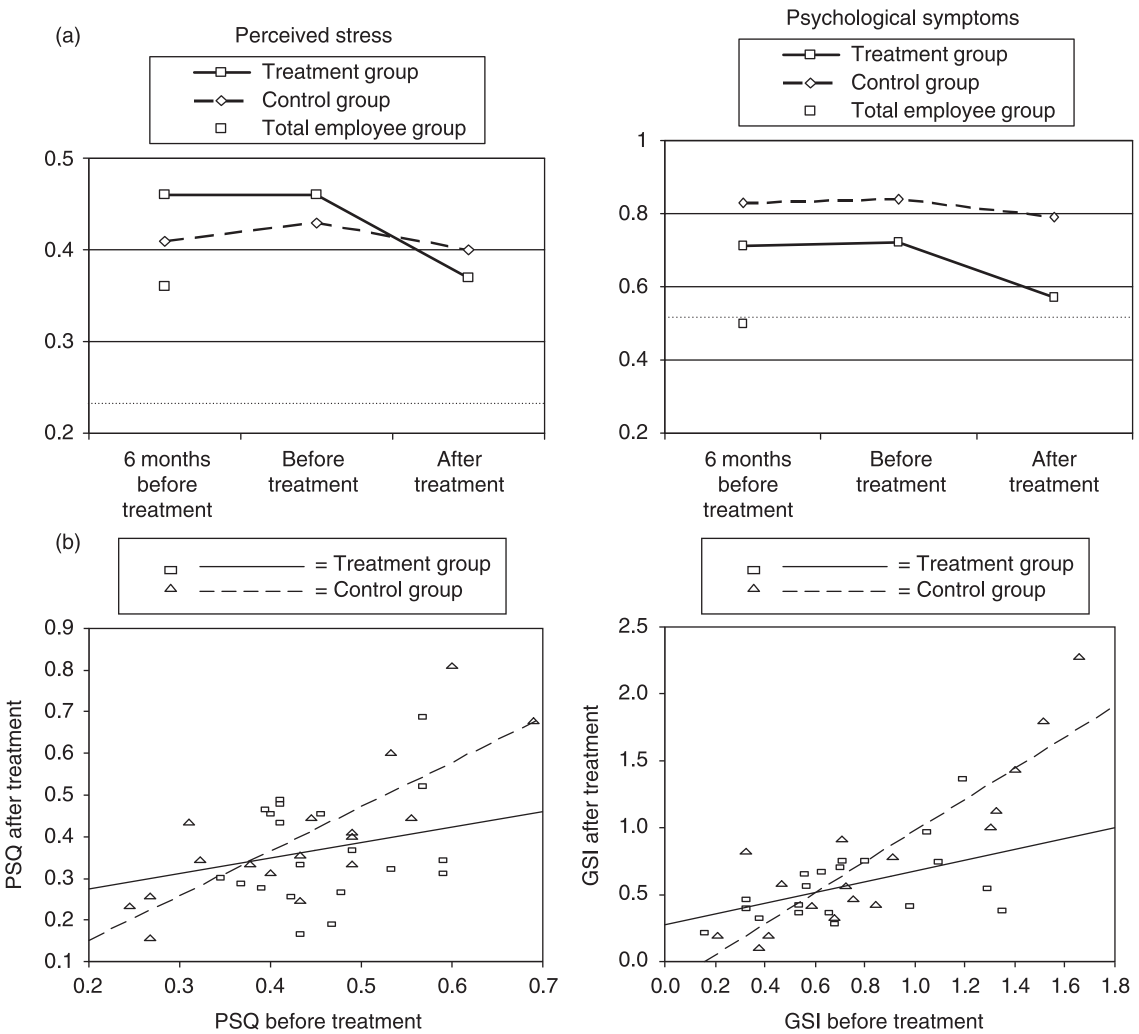

Fig. 2a. Left: Level of stress of treatment and control groups before and after the intervention measured by the Perceived Stress Questionnaire (PSQ). The total employee group, assessed at initial screening, is marked by □ and the sex- and age-matched normative group by a dotted line. *Right*: Psychological symptoms of treatment and control groups before and after the intervention were measured by the Global Severity Index (GSI) of the Symptom Check List-90. The score of the total employee group, assessed at initial screening, is marked by □ and the normative group by a dotted line.

Fig. 2b. Left: Scatter plot with regression lines of the treatment and control group pre-treatment and post-treatment scores on Perceived Stress Questionnaire (PSQ). *Right*: Scatter plot with regression lines of the treatment and control group pre-treatment and post-treatment scores on the Global Severity Index (GSI) of the Symptom Check List-90.

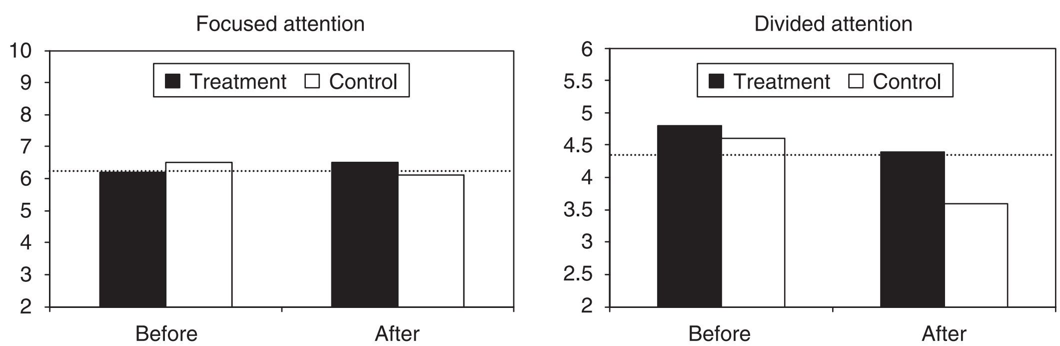

Fig. 3. Left: Free recall under focused-attention conditions of treatment and control groups before and after the intervention (mean number of recalled words). *Right*: Free recall under divided-attention conditions of treatment and control groups before and after the intervention (mean number of recalled words). Age-matched normative performance levels are indicated by dotted lines.

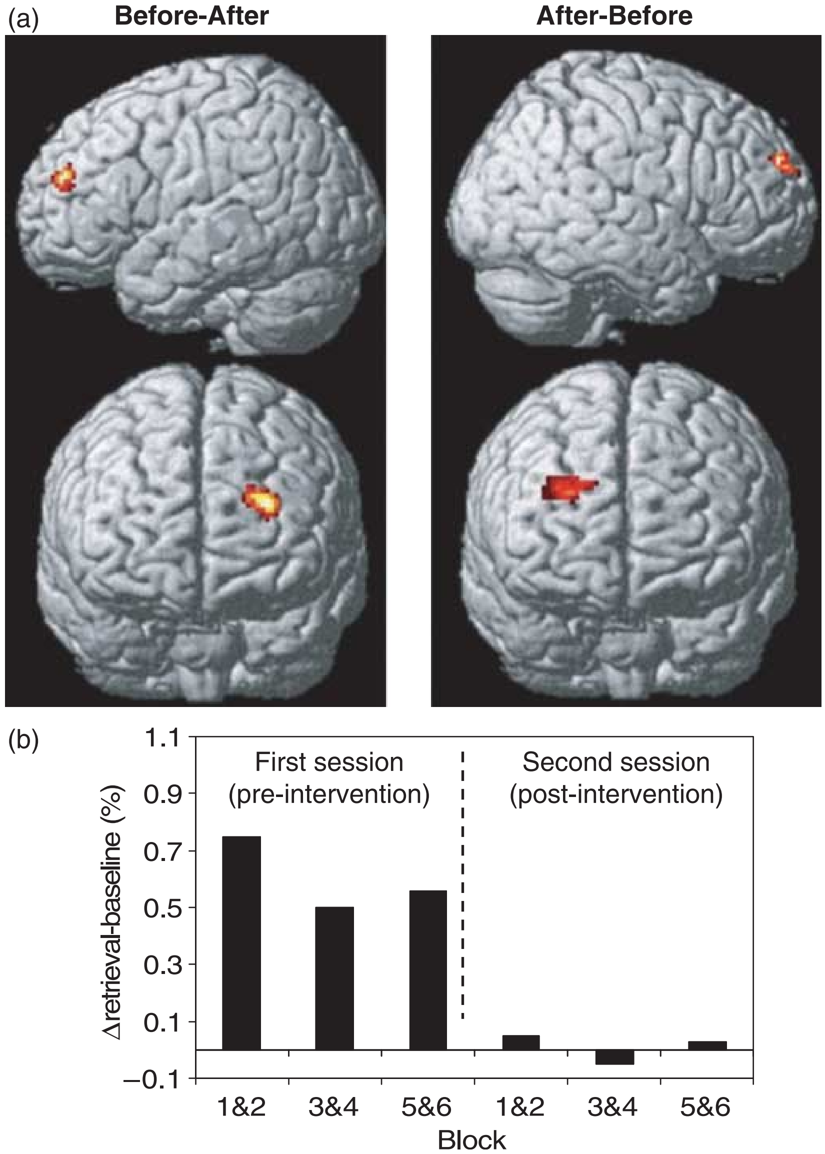

Fig. 4a. Left: Increased left frontal activation (MNI x,y,z = –26,48,24) during retrieval before versus after the intervention. *Right*: Increased right frontal activation (MNI x,y,z = 26,58,30) during retrieval after versus before the intervention. The activations are displayed on SPM cortical rendering images ($p < 0.05$ corrected at the voxel level).

Fig. 4b. Within-session plot of the magnitude of left prefrontal activation pre- and post intervention.

Table 2. *Effect-size values (ES) for the treatment and control group on the Perceived Stress Questionnaire (PSQ), Global Severity Index (GSI) of the Symptom Check List-90, and focused and divided attention in the episodic-memory test*

Instrument	Treatment group ES	Control group ES
PSQ	1.16	0.26
GSI	0.47	0.11
Focused attention	0.31	−0.40
Divided attention	−0.29	−0.66

DISCUSSION

These results show that short-term affect-focused intervention can lead to significant reductions of perceived stress as well as psychological symptoms. According to the ES values, it seems that the intervention had largest effect on stress level. A high level of stress, as seen in the treatment and control groups prior to the intervention, seems to be accompanied with elevated levels of psychological symptoms, indicating that such stress levels can result in distress and sick-leave (Fig. 2a). A moderately elevated level of stress, as demonstrated in the total employee group, did not show this pattern.

After the intervention, the level of stress in the treatment group was lowered to the same level as the total employee group. The level was still elevated compared to the normative group (Fig. 2a), which may be due to environmental and organizational factors that affect employees in the targeted working areas. With the *t*-test, we could not find any significant post-treatment differences in PSQ and GSI scores between the treatment and control group. But the ANCOVA analyses revealed a significant GSI score/group interaction. The reduction of the post-treatment scores in the treatment group was particularly accentuated when the pre-treatment scores were high (Fig. 2b). We found a similar pattern, although not significant, regarding the PSQ scores (Fig. 2b). These findings indicate that the Affect School has most effect on subjects with high levels of stress and psychological symptoms.

A model how affect-focused intervention could influence affective regulation has been presented (LeDoux, 1996). Increased affect awareness may create synaptic potentiation in brain pathways that control the amygdala and enhance medial prefrontal cortical control of the amygdala. An explanation of the treatment effects in the present study could therefore be that the Affect School increased the explicit knowledge of affects, that is, increased affect awareness improved the ability to perceive and express affects through an effect on the amygdala of the temporal lobe memory system and other cortical areas that are involved in conscious awareness. Using a dynamic systems approach, affects have been proposed to be a part of the same dynamic as perception, action, cognition and social behaviour (Thelen & Smith, 1998). Affects are described as relatively stable patterns that are continually construed by complex and dynamic interactive self-organized processes, which are fluid, context-sensitive, and non-linear. Improved affect awareness could therefore be used to challenge maladaptive cognitions, which may lead to a restructuring of dysfunctional schemes and consequently act as the basis of new self-organizations resulting in new strategies to handle stressful situations.

Psychological stress activates the hypothalamic-pituitary-adrenal (HPA) axis and related steroids play important roles in many brain functions, such as emotion and cognition. The hippocampus is particularly sensitive to circulating levels of plasma cortisol (Alderson & Novack, 2002). Reduced stress, through improved affect awareness, may have decreased the activation of the HPA-axis, resulting in lowered secretion of glucocorticoids (GC) leading to reduced effects on GC sensitive processes. Our observed pattern of results suggests that the prolonged levels of stress and symptoms of the participants in the control group led to impaired cognitive performance. It is noteworthy that the cognitive decline was observed when the attention had to be divided during memory encoding, suggesting that high levels of stress may be especially detrimental under attention demanding conditions. In contrast, in the treatment group, the reduction of stress, symptoms and presumably levels of GCs may have prevented cognitive decline. The ES values for the PSQ and episodic-memory test in the treatment (ES = 1.16 and -0.29 respectively) and control group (ES = 0.26 and -0.66 respectively) support that conclusion. However, until confirmed in future studies, preferably with additional measurement points, the present results on changes in memory performance should be regarded as tentative.

The results from the fMRI-sessions converged with those from the overall episodic memory testing in showing that the level of memory performance was the same after as before the intervention. Nevertheless, the pre- and post-intervention retrieval activation patterns indicated treatment-related changes within the prefrontal cortex (Fig. 4a,b). In keeping with numerous studies of healthy young volunteers (Cabeza & Nyberg, 2000), retrieval was associated with increased right prefrontal activation after the intervention. By contrast, left prefrontal activity was more pronounced prior to the intervention. Left prefrontal activation is typical for semantic memory retrieval (i.e., retrieval of general knowledge), and patients with psychogenic amnesia have been found to activate left rather than right frontal regions during episodic memory retrieval (Markowitsch, 1999). One possible interpretation of the altered prefrontal activation pattern, therefore, is that the reduction of stress altered the way the memory task was solved from more neutral "semantic-like" retrieval to richer "episodic-like" retrieval. Alternatively, since more demanding episodic retrieval has been associated with left frontal activation (Nolde, Johnson & Raye, 1998), it is possible that the higher involvement of the left prefrontal cortex before than after treatment is a reflection that the subjects found the retrieval task less demanding after the intervention. In the absence of a control group, it cannot completely be ruled out that the observed effect was an effect of repeated testing rather than an effect of the intervention, but the fact that different items were used during the first and second session suggest that the effect was not simply a repetition effect. Moreover, within-session plots of the magnitude of left prefrontal peak activity indicated that the effect was tied to the intervention, rather than to a gradual decrease over time across test blocks. It should be noted that the fMRI scanning was performed within a rather long time before and after the intervention (5 weeks). This was caused by a restricted access to the fMRI equipment. It cannot be ruled out that this affected the results. An interesting topic to explore in future brain imaging studies is whether treatment-related effects, as in the present study, are seen in the prefrontal cortex rather than in the hippocampal region. Prefrontal cortex functioning has been shown to be affected by stress levels (Lupien & Lepage, 2001), so it is reasonable that a reduction in stress could affect prefrontal functional activity. Why no effect was seen in the hippocampal region is not clear. One factor may be poor power to detect an effect. It is also more common to observe prefrontal activity than hippocampal activity during episodic memory retrieval (Cabeza & Nyberg, 2000), pointing to the possibility that the current imaging protocol may not have been optimal for detecting treatment-related hippocampal effects. One possibility for future studies would be to include a functional protocol that taps spatial processing (cf. Lupien *et al*., 1998).

Several limitations of the present study should be noted. One is that a relatively small number of participants were included, especially in the fMRI part of the study. Relatedly, all participants did not complete all rating forms, which additionally reduced the number of observations. Furthermore, although the control group, except for the intervention program, was given the same attention as the treatment group, an additional control group exposed to another kind of intervention would be preferable in order to identify specific treatment effects. Due to these and other potential limitations we regard our results as preliminary and the study should be replicated with a larger number of participants.

With these caveats in mind we conclude that stress disorders are a significant societal problem for which many kinds of actions have to be taken, but at least for individuals who are relatively well-functioning, one effective action seems to be short-term affect-focused group intervention such as the Affect School. An important future question is whether such intervention can restore cognitive functions in high-stress individuals with impaired cognition. More generally, the work presented here represents an example of the challenge to understand how and where the effects of therapeutic interventions occur.

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