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Biofeedback Training in Crisis Managers: A Randomized Controlled Trial

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Abstract Working in crisis environments represents a major challenge, especially for executive personnel engaged in directing disaster operations, i.e. crisis managers. Crisis management involves operating under conditions of extreme stress resulting, for instance, from high-level decision-making, principal responsibility for personnel, multitasking or working under conditions of risk and time pressure. The present study aimed to investigate the efficacy of a newly developed biofeedback training procedure based on electrodermal activity, especially designed for the target group of crisis managers. The training comprised exercises promoting acquisition of control over sympathetic arousal under resting conditions and during exposure to visual, acoustic and cognitive stressors resembling situations related to crisis management. In a randomized controlled design, 36 crisis managers were assigned to either a biofeedback training group or waiting list control group. Subjective stress was assessed using the Perceived Stress Scale. In the training group, stress level markedly decreased; the decrease remained stable at follow-up 2 months after the training. The results indicate that biofeedback training in crisis management is an effective method for stress management that may help to reduce vulnerability to stress-related performance decline and stress-related disease.

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Introduction

Working in disaster environments including natural catastrophes, terror attacks or industrial accidents represents a major challenge for the professionals involved, such as relief-forces, firefighters and medical or paramedical staff (Alexander and Klein 2001). This especially applies to crisis managers, i.e. executive personal engaged in directing disaster operations. Their duties include the mobilization and coordination of first responders, allocation of tasks, communication with authorities, evaluation of the immediate needs of the affected population and ongoing risk assessment in order to maintain the security of victims and emergency personal. Crisis management involves high-level decision-making and principal responsibility for personnel, thereby requiring advanced organizational and leadership skills. Similar to emergency workers and paramedics, during their operations crisis managers are exposed to severe suffering, injury and death, which, in many cases, constitute traumatic experiences (Berger et al. 2012). Holding a leadership position also involves other challenges; in addition to great responsibility for staff and human lives, crisis managers may also be faced with conflicts of interest, insufficient manpower, ambiguous or conflicting roles and extremely high expectations from others (Janka et al. 2015).

Considering these profound challenges, the necessity of efficient stress management skills in crisis managers is beyond question. While detailed guidelines are available aimed at optimize crisis management activities (Saynaeve 2001; Ritchie et al. 2006; Critical Response in Security and Safety Emergencies 2011), specific techniques applicable to stress management training in this professional group have to date been subject to scant development. Biofeedback may be a useful tool for this purpose, as it allows individuals to efficiently improve awareness and acquire control of changes in autonomic nervous system activity related to stress from multiple sources (Schwartz and Andrasik 2005). The objective and time-economic characteristics of biofeedback appear to render it eminently suitable for the target group of crisis managers.

Biofeedback as a standalone technique, or as a component of multimodal stress management training programs, has been applied in various professional groups. Empirical studies conducted, inter alia, in health-care professionals, pilots, soldiers and police, indicate beneficial effects in terms of reducing self-reported stress burden (Bouchard et al. 2012; Cutshall et al. 2011; Kotozaki et al. 2014; Lemaire et al. 2011; van der Zwan et al. 2015; Weltman et al. 2014), improving stress management abilities (Bouchard et al. 2012; Cowings et al. 2001; Cutshall et al. 2011), effecting positive changes in emotional states (Cutshall et al. 2011; Kotozaki et al. 2014; Ratanasiripong et al. 2012; van der Zwan et al. 2015; Weltman et al. 2014), enhancing professional performance (Cowings et al. 2001; Kellar et al. 1993), and having a positive impact on the activity of psychophysiological systems (Kotozaki et al. 2014). Just as in healthy professionals, biofeedback-based stress management training has been successfully applied in various clinical populations, for example for stress control in patients suffering from post-traumatic stress disorder (e.g., Ginsberg et al. 2010; Tan et al. 2011; Reyes 2014; Zucker et al. 2009), chronic pain (e.g., Berry et al. 2014), cardiovascular disease (e.g., Moravec 2008), headache (e.g., Lehrer et al. 1994; Nash and Thebarge. 2006), or hypertension (e.g., Garcia-Vera et al. 1998).

To the best of our knowledge, biofeedback-based stress management has not yet been systematically applied and investigated in crisis managers. The present study tested a biofeedback training program that was specifically developed for this group with the aim of improving self-control of the autonomic arousal that occurs in response to stressful events experienced at work. The working conditions of crisis managers are characterized by significant but time-limited stressor exposure during disaster relief operations, whereas the stress burden is considerably lower during regular working activities between operations, in which managers commonly perform executive functions such as administrational and personnel management (Janka et al. 2015). Due to this work pattern, involving rapid switching between extremely demanding operations and everyday work of lower demand, the training was designed in order to strengthen the ability to limit autonomic arousal during acute stress, and moreover to facilitate a quick return to the initial state thereafter, to optimize resources for recovery.

The training program comprised exercises aiming to promote deliberate control over electrodermal activity (EDA) under resting conditions and during exposure to various experimental stress conditions. Visual, acoustic and cognitive stressors were designed for this purpose, which resembled situations related to crisis management. EDA was chosen as a target parameter of biofeedback, because it represents a valid and well-established indicator of stress-related changes in sympathetic nervous system activity (Berntson et al. 2007; Dawson et al. 2007). Furthermore, its suitability for assessing autonomic responses to crisis-related stressors and cognitive challenge in crisis managers has been previously documented (Janka et al. 2015).

As a tool for primary prevention, biofeedback-based stress management in crisis managers may confer beneficial effects in terms of conservation of physical and mental health (c.f., Schwartz and Andrasik 2005). In addition, it may help to reduce vulnerability to stress-related performance decline. Autonomic overarousal is associated with performance reductions in executive cognitive functions including logical-reasoning, decision-making and multiple-tasking, which are of profound importance in crisis management (McClelland 2000). Deleterious effects of high stress levels on work performance have been shown, for example, in the fields of aviation, the armed forces and medicine (Svensson et al. 1993; LeBlanc 2009; LeBlanc et al. 2012). Taking into account the potential consequences of stress-related mistakes or incorrect decisions for individual human lives and public safety, the issue of stress control is particularly crucial in crisis management.

In this study, the efficacy of biofeedback training in crisis managers was assessed using a randomized design; participants were assigned either to an intervention group or a waiting list control group. Those in the intervention group received nine biofeedback training sessions during a 6-week period. Subjective stress burden was assessed by a questionnaire immediately before and after the training procedure and - in order to evaluate the stability of training effects - at a follow-up 2 months later. Due to the limited number and availability of professional crisis managers, the study sample was recruited from, and training sessions were performed in, four different institutions in Austria, Germany and Luxembourg.

Methods

Participants

Thirty-six crisis managers (31 men, 5 women) participated in the study. They were randomly assigned to a group who received biofeedback training and a control group. The sample comprised golden and silver commanders of institutions involved in the crisis management of major incidents. In their middle and higher management positions, these individuals were required to have staff and decision-making responsibilities, and furthermore to possess experience in the management of actual crises. Exclusion criteria for participation included any kind of serious physical disease or psychiatric disorder (e.g., posttraumatic stress disorder), the use of medication affecting the central nervous or autonomic nervous systems. Health-related information was obtained by means of an anamnestic interview and a comprehensive checklist. Moreover, it was determined *a priori* that the data of participants involved in crisis management operations during the study period would be excluded from the analysis. This was applicable to one crisis manager.

Table 1 lists the organizations and positions of the crisis managers; demographic and professional information is given in Table 2. The biofeedback and control groups did not differ significantly in terms of age, educational level, experience in crisis management, or total work experience (c.f. Table 2).

The crisis managers were recruited at institutions in Austria (red cross graz, N = 5; red cross, fire department, police department Imst, N = 10), Germany (red cross freising, N = 11) and Luxembourg (psychological support group of civil protection, N = 10). During recruitment, local representatives of the project presented the study to the heads of these institutions and asked them to inform their crisis managers about its aims and the criteria for participation. Thereafter, the project representatives directly contacted interested crisis managers and informed them in more detail about the training content and study design, including assessment instruments, study duration and points of measurement. Randomization procedures were carried out separately at each of the aforementioned institutions, such that half of the participants recruited at each location were assigned to the biofeedback group, and half to the control group. Participants in the biofeedback group were informed about the technical equipment and training procedure, including homework; those in the control group were informed about the possibility of participating in the training after completion of the study. All participants provided written informed consent.

Biofeedback Training

The biofeedback procedure was conducted in accordance with the guidelines of the Association for Applied Psychophysiology and Biofeedback (2003). The training program comprised nine 45-min training sessions, which were conducted over a 6-week period. Two sessions were completed per week; the interval between sessions ranged from 2 to 4 days (M = 3.06 days, SD = 1.06 days). Relatively long intervals between training sessions were chosen, as the theory of memory consolidation predicts that knowledge acquired during a longer period may be more stable and resistant to interference from destructive factors (e.g., McGaugh 2000). A gap of several nights between sessions also seemed to be appropriate considering the impact of sleep on the consolidation of procedural skills, i.e. in terms of strengthening memory traces and triggering additional learning, thereby improving behavioral performance (Walker and Stickgold 2004). Moreover, the intervals were long enough to enable adequate practice-transfer of the acquired skills, in the sense that the learned strategies could be tested and applied during work routines. Each participant consistently received training at the same time of day. By this means, circadian effects on the EDA signal, for example due to

Table 1 Professional organizations and positions of the crisis managers

Organization	N (%)	Position	N (%)
Rescue service	16 (44%)	Operation controller	22 (61%)
Fire brigade	10 (28%)	Commandant	9 (25%)
Other organizations (e.g., civil protection, water rescue service, mountain rescue service)	6 (17%)	Chief of the office	5 (14%)
Police	4 (11%)		

Table 2 Demographic data: means (standard deviation), F[1,34]-values, and p-values of the group comparisons

	Biofeedback group	Control group	F[1,34]	p
Age (years)	38.00 (11.92)	41.11 (8.38)	0.82	0.37
Time of education (years)	14.86 (2.59)	15.44 (4.05)	0.27	0.61
Total work experience (years)	16.89 (9.57)	21.83 (9.42)	2.44	0.13
Duration of crisis management (years)	9.67 (8.00)	10.06 (6.68)	0.03	0.88
Involvement in operations (number)	47.61 (100.35)	33.56 (66.38)	0.25	0.62

fluctuations of cortisol release, could be controlled, where such effects may interfere with optimal training.

The first session included psychoeducation concerning the psychophysiological stress concept, the role of stress in health and performance, the functional principle of biofeedback, and EDA as an indicator of autonomic arousal. Moreover, a "stress test" was conducted in order to show participants their individual stress response. For this purpose, EDA was recorded during resting conditions (1 min), during exposure to two experimental stressors (crisis-related noises and mental calculation task; 2 min each), and during recovery periods following the stressors (1 min each). While the signal was not fed back during the test, crisis managers had the opportunity to review its course thereafter. The "stress test" was not applied as a psychophysiological assessment instrument, instead serving as a didactical tool with the aim of familiarizing the participant with the EDA signal and providing insight into the relationship between psychological stress and bodily arousal. Nonetheless, relative (percent) changes in EDA during the two stress conditions, and following recovery periods with respect to baseline in the training group, are depicted in Fig. 1 (for quantification of changes, c.f. Linden et al. 1997). EDA increased during both stress conditions and decreased thereafter; the response was stronger during the mental calculation versus noise exposure.

In sessions 2–4, crisis managers underwent classical biofeedback exercises to acquire control over EDA under resting conditions. They could choose between two signal display options: in the first version, EDA was presented as a line, which had to be lowered to the greatest possible extent by physical or mental relaxation. In the second version, EDA was fed back as a lotus flower that opened with decreased EDA and closed with increased EDA. In order to facilitate generalization, "voluntary control exercises" were included during which participants were instructed to lower their psychophysiological stress level in the absence of direct feedback. During these exercises, the EDA signal was recorded without being displayed on the screen, and reviewed thereafter. Within each session, three exercises each of 9 min duration were carried out.

Sessions 5–9 comprised training elements specifically designed for the target group of crisis managers. These exercises included visual, acoustic and cognitive stressors, most of which resembled situations related to disaster operations. Participants were instructed to keep the EDA signal as low as possible during stressor exposure and to reduce it to pre-stressor baseline as quickly as possible during the following recovery phase (overall exercise duration, 9 min). Pictures from disaster scenarios (e.g., flood, plane crash, terror attack) were chosen as visual stressors, and various crisis-related noises (e.g., screaming people, helicopter landing, ringing phone) as acoustic stressors. Cognitive stress was generated through mental arithmetic (serial subtractions) and verbal (saying alphabet backwards) challenges. Mental imagery associated with stressful events (individually chosen work-related burdensome situations) was included as an additional stressor. In addition to the training within the sessions, during the whole training period crisis managers were continuously encouraged to

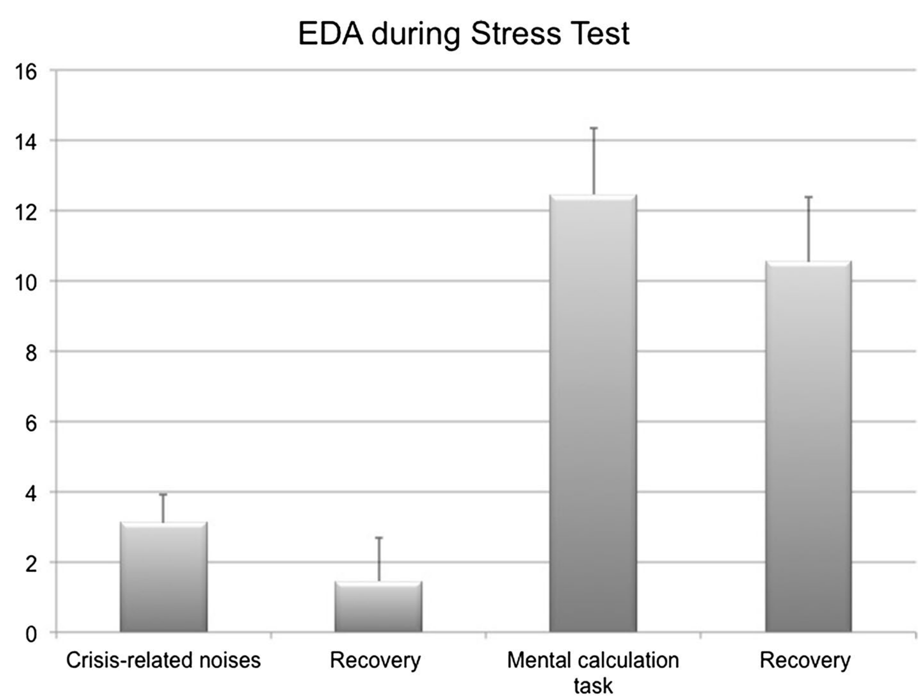

Fig. 1 Relative changes from baseline in the EDA signal during the "stress test" (*bars* represent standard errors of the mean)

apply the acquired relaxation strategies within real stressful situations that occur during their work routine. This procedure was implemented for generalization of the learned techniques to daily life.

The biofeedback system SOFTmed Physiosystem (Insight Instruments, Hallein, Austria) was applied for the training. This device uses a finger sensor (electrode surface, 50.3 mm^2) to measure EDA; the sensor was attached to the fourth finger of the non-dominant hand. Applied amperage was 8 µA (DC); the data was digitized at a frequency of 10 Hz. While the signal was displayed to the participants as a moving average of 1 s, the raw data was stored without further processing.

Trainings were conducted in a one-to-one setting by three psychologists and one social worker at the institutions involved in recruitment of the crisis managers (see Participants section). Trainers were instructed and supervised during the entire training by experienced biofeedback trainers at UMIT - University of Health Sciences Medical Informatics and Technology (Hall in Tirol, Austria) and Insight Instruments (Hallein, Austria). "Train-the-trainer workshops" of 4-day total duration were arranged prior to the study.

The crisis managers in the control group did not receive any intervention. They were assigned to a waiting list and were given the option to receive the biofeedback training after completion of the observation period.

Points of Measurement and Outcome Parameters

The study design included three points of measurements for both study groups: (1) pre-test (before training onset), (2) post-test (after completion of the training, i.e. 6 weeks after the pre-test), and (3) follow-up (2 months after post-test).

The German version of the perceived stress scale (PSS, Cohen et al. 1983) was applied to evaluate possible changes in perceived stress burden across the observation period. The PSS is a widely used questionnaire for quantifying general subjective stress, with ten items, pertaining to feelings and thoughts, via which to appraise situations encountered in one´s life as being stressful, unpredictable and uncontrollable. Responses are given on five-point Likert scales.

Changes in sympathetic tone during the biofeedback exercises were quantified using two indices: At first, the proportion of time during which the EDA signal decreased during the respective 9-min period was computed. Using Excel software (Microsoft, Redmond, WA, USA), the number of negative differences between successive data points was calculated and divided by the total number of successive differences. In addition, the maximal relative decrease (%) during the 9-min exercise period relative to a 60 s baseline was computed (c.f. Linden et al. 1997). Mean values of both indices will be exemplarily presented for two exercises aiming at EDA control under resting conditions (sessions 2 and 4) and one exercise carried out under stress conditions (mental arithmetic, session 7). This analysis was restricted to a descriptive level. Changes in the described indices during the course of the entire training procedure, i.e. learning curves, were not analyzed. This would not have been appropriate due to the considerable differences in the content of the exercises of sessions 5 to 9 (EDA control under stress conditions).

Data Analysis

Statistical analysis was based on analysis of variance (ANOVA) with the experimental group (biofeedback group vs. control group) included as a between-subjects factor and point of measurement (pre-test, post-test, follow-up) used as a within-subjects factor. The score of the PSS served as the dependent variable. Post hoc t-tests were applied to investigate changes in the PSS score between points of measurement separately for both study groups. Alpha was set at 0.05 for all analyses. Effect-sizes were indicated by partial eta squared values computed in the ANOVA, and by Cohen´s d for the changes in the PSS score between points of measurement in the biofeedback group (pre-test vs. post-test, pre-test vs. follow-up).

Results

Figure 2 depicts the changes in the PSS score across the observation interval in both study groups. In the biofeedback group, the post-test score was markedly decreased compared to the pre-test score, and the score slightly increased at follow-up. In the control group, a small increase in the score was observed across the observation interval. The ANOVA revealed an interaction between group and point of measurement ($F[2, 68] = 3.32$, $p = .042$, partial eta squared = 0.089). Post-hoc t tests comparing the pre-test value with those obtained at the post-test and follow-up revealed changes in the biofeedback group (pre-test vs. post-test: $t[17] = 3.10$, $p = .007$; pre-test vs. follow-up: $t[17] = 2.27$, $p = .036$); the difference between the post-test and follow-up was not significant $t[17] = -1.41$, $p = .18$. None of the post-hoc comparisons revealed significant changes across time in the control group (pre-test vs. post-test: $t[17] = -0.27$, $p = .79$; pre-test vs. follow-up: $t[17] = -0.94$, $p = .36$; pre-test vs. follow-up: $t[17] = -0.69$, $p = .51$). Cohen´s d computed in the biofeedback group was 0.86 for the change between the pre-test and post-test and 0.63 for the change between the pre-test and follow-up.

The mean proportions of time during which the EDA signal decreased in the exercises carried out under resting conditions were 72.9% (SD = 11.6%) in session 2 and

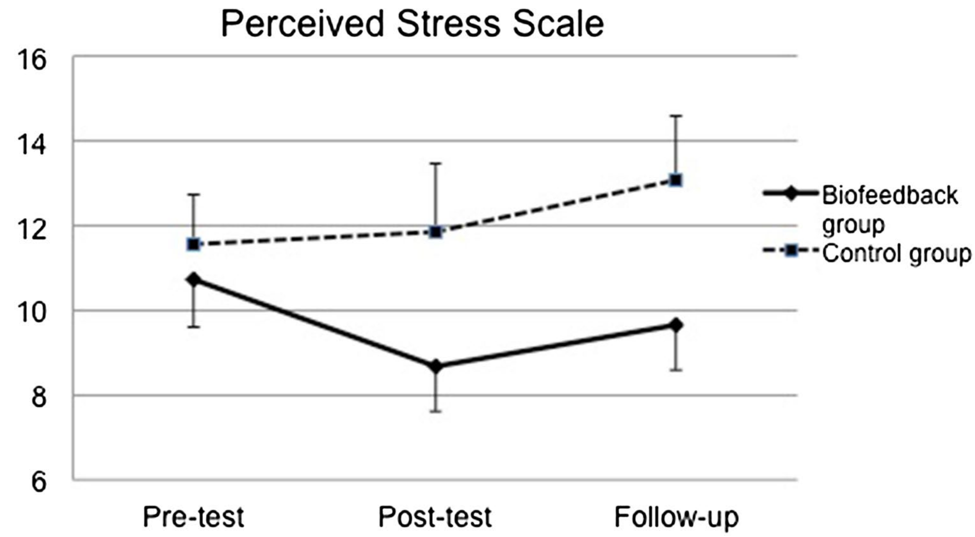

Fig. 2 Changes in PSS scores across the observation period in both study groups (*bars* represent standard errors of the mean)

76.9% (SD = 9.37%) in session 4. For the exercise conducted during mental arithmetic (session 7), the proportion of time of signal decrease was 66.0% (SD = 6.1%). The mean maximal EDA decreases with respect to baseline were −8.20% (SD = 8.71%), −12.24% (SD = 6.74%) and −15.51% (SD = 14.21%) for sessions 2, 4 and 7, respectively.

Discussion

The present randomized controlled trial evaluated the efficacy of a newly developed biofeedback training program especially designed for a target group of crisis managers. These managers, who received nine sessions of EDA based biofeedback training, exhibited a significant and essentially stable reduction in subjective stress burden as indexed by the PSS. According to the traditional classification system (Cohen 1988), the magnitude of the decrease in the PSS score during the training period corresponds to a large effect size (Cohen´s d 0.86), whereas the difference between the pre-test and the 2-month follow-up represents a medium to large effect (Cohen´s d 0.63). Therefore, it can be concluded that biofeedback may constitute a beneficial method for application as a standalone technique or as a component of multimodal stress management training programs in crisis managers.

Trainees exhibited a maximal EDA decrease during biofeedback exercises with respect to baseline of −8, −12 and −16% in the sessions 2, 4, and 7, respectively. Interestingly, crisis managers already demonstrated a strong ability to reduce sympathetic arousal from the beginning of the training, which is also indicated by a time-slice of EDA signal decrease of 72 and 76% for the exercises conducted under resting conditions in sessions 2 and 4, respectively. This is in line with observations made in a previous study in which psychophysiological stress responses were compared between crisis managers and managers from other disciplines (Janka et al. 2015). Crisis managers exhibited far smaller EDA and heart rate responses to crisis-related and non-specific visual and acoustic stressors, as well as during cognitive challenge. Even though changes in psychophysiological reactivity over time were not systematically analyzed, it may be considered that the present training led to further reduction of stress responses, particularly due to the exercises aiming at EDA control during stressor exposure. However, as an alternative or additional mechanism of reducing perceived stress, it may be that the participants learned to more efficiently apply their pre-existing ability to control autonomic tone as a strategy for stress management in daily life. Indeed, a major component of the training sessions concerned explicitly instructing participants to make use of their acquired relaxation strategies in the context of burdensome situations occurring during their work routine. In unstructured interviews conducted after completion of the training, most participants explained that this aim was actually achieved, and they were able to refer to numerous situations in which they made use of these strategies.

The beneficial effect of biofeedback on perceived stress may be discussed in the context of the specific professional conditions encountered by crisis managers. These conditions are commonly characterized by rapid switching between regular management duties and extremely demanding disaster relief operations, which requires sudden activation of mental and physical resources and rapid return to the initial state. It has been argued that this work pattern contributes to psychophysiological stress resistance, in terms of comparatively low psychophysiological reactivity and the development of distinct coping-skills (Janka et al. 2015). In this context, psychological flexibility may play an important role in the context of efficient mental and energetic adjustments to changing situational demands, quick activation of behavioral resources to suit current requirements, coping with negative emotions and burdensome experiences, and efficient recovery during the aftermath of such events (Rozanski and Kubzansky 2005; Kashdan and Rottenberg 2010). A high degree of flexibility is believed to limit stress reactivity and to mitigate against the deleterious effects of recurrent stress (Bonanno et al. 2004; Rozanski and Kubzansky 2005; Kashdan and Rottenberg 2010). Biofeedback training conducted as described herein may support the development of flexible behavioral adjustment, because it helps to prevent autonomic overarousal during periods of high requirement and moreover facilitates return to the baseline state. In this manner, the training may enhance allostatic capacity by helping to conserve or regain internal stability of the organism even when situational challenges are extreme.

Although the present training sessions were conducted by professionals from the fields of psychology and social work, it is important to note that none of the trainers had undergone comprehensive education in biofeedback. Instead, they were only instructed within the framework of workshops of a few days duration and supervised by educated experts during the 6-week training period. This is relevant with respect to the practicability of biofeedback training for crisis management; our data suggest that training may be successfully undertaken in a semi-professional context with support from experienced experts. Even though a marked effect size was obtained for the difference in PSS score between the pre-test and follow-up, the score slightly rose during the follow-up period, indicating that stress burden somewhat increased. This points to the utility of additional "booster" sessions after completion of the actual training program. These sessions may be used to consolidate acquired skills and promote their implementation during stressful events.

An obvious limitation of the study is the relatively small sample size (36 crisis managers), which may restrict the generalizability of the results. By definition, the findings do not allow any conclusions to be drawn pertaining to populations other than healthy crisis managers. However, this group may have possessed strong coping resources and high stress resistance from the outset. As delineated above, earlier research suggested that crisis managers may exhibit lower psychophysiological stress reactivity and generally higher stress tolerance than other professional groups (Janka et al. 2015). Moreover, crisis managers suffering from post-traumatic stress disorder and other psychiatric conditions were excluded from participation in the study; as such, individuals with particular deficits with respect to coping with stress were not included. It is possible that efficient stress management among our sample of crisis managers may have facilitated the learning process during biofeedback training. By definition, this notion must remain speculative, because only crisis managers were investigated in the study. It would certainly be informative in future research to compare the effects of training in crisis managers with those in other professional groups, where for example paramedics or first responders would be of interest. In addition, self-reported stress burden was applied as a single parameter for quantification of training effects. A more broadly conceived outcome assessment should be considered in future studies. It would be worthwhile, for example, to also explore effects on physiological markers of stress level such as salivary cortisol or heart rate variability (Kotozaki et al. 2014). Subjective and bodily indicators of mental and physical health may also be regarded in addition to self-reported wellbeing and emotional state (van der Zwan et al. 2015; Weltman et al. 2014). Concerning the profound importance of high-level crisis management for public safety, possible enhancement of professional performance due to stress control may also be of interest (Bouchard et al. 2012; Cowings et al. 2001).

Another limitation relates to the evaluation of changes in EDA during the biofeedback exercises. Due to the differing contents of the nine training sessions, the study design could not quantify training effects in terms of stronger or quicker reduction of the EDA signal during the course of the entire training procedure. Therefore, the actual influence of improvements in the ability to deliberately control sympathetic arousal, or the magnitude of the decrease in stress reactivity during training, on the reduction of perceived stress could not be documented. The validity of the two indices of EDA changes during the exercises is limited; this is particularly relevant for session 7, in which biofeedback training was conducted during stress exposure. Here, EDA components related to stress and relaxation could not be distinguished. Finally, data reflecting the maturation of skills from one session to the next, and their retention or attrition, were not obtained, this could be a target for future studies.

In summation, the study supports the notion that biofeedback can be beneficial as a measure of stress control in crisis managers, thereby facilitating them in psychophysiologically adjusting to the profound challenges of their vocation. A combination of training elements that decrease sympathetic arousal under resting conditions with such aiming to limit responses during controlled stress-induction may be particularly helpful. In addition to the reduction of subjective stress burden and vulnerability to stress-related diseases, biofeedback-based control of autonomic arousal may also limit susceptibility to stress-related decline in professional performance and help to ensure adequate preparedness for major incidents and maintenance of public security.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in the study were in accordance with the ethical standards of the 1964 Helsinki declaration and its later amendments. The study was approved by the ethics committee of UMIT - University of Health Sciences, Medical Informatics and Technology; all participants provided written informed consent.

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