Does Attention Training Enhance Stress Resilience and Performance in Unforeseen Safety-Critical Situations?

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DOES ATTENTION TRAINING ENHANCE STRESS RESILIENCE AND PERFORMANCE IN UNFORESEEN SAFETY-CRITICAL SITUATIONS?

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Dealing successfully with unforeseen safety-critical situations is a prerequisite for save pilot performance. Studies applying new attention-based training approaches have revealed positive effects on emotion regulation and on concentration abilities. Hence, the question arises to what extent attention training would facilitate cognitive adaptation processes, thereby attenuating emotional stress responses and reducing performance decrements in unforeseen flight situations. Twenty-four pilots will be randomly assigned to two groups and will either be trained in attention regulation or in relaxation techniques. “Home training” will be followed by training in the flight simulator. Performance ratings, video and audio recordings, subjective data, and EDA data will be collected. It is expected that the experimental group “Attention” will show lower stress responses and better performance compared to the control group “Relaxation” when faced with an unexpected situation in the final simulator test. It is suggested, that attention training positively influences cognitive appraisal processes and cognitive flexibility.

Unforeseen safety-critical situations with high complexity are among the most stressful challenges in high-risk environments such as aviation (Fornette, Bourgy, Jollans, Roumes, & Darses, 2014) and can severely hamper an operator’s performance (Casner, Geven, & Williams, 2013). Recent incidents and accidents in civil aviation, classified as “loss of control in flight”, have provoked safety experts to sound the alarm (Landman, Groen, van Paassen, Bronkhorst, & Mulder, 2017). They strongly emphasize that there is a need to reinforce a pilot’s skills in dealing successfully with unforeseen safety-critical situations. Cognitive adaptation training could be a valuable supplement to the conventional training. In this regard, Fornette, et al. (2014) stressed the implementation of new training approaches based on attention regulation. However, the effects of these training techniques have not yet been evaluated in detail. Hence, the question arises to what extent attention training would facilitate cognitive adaptation processes which may enhance stress resilience and performance in unexpected flight situations.

Safety in all flight situations is a challenging demand. Operators, once selected, have to be intensively trained in order to manage the challenges faced in the time-dynamic working environment. Training so far mainly concentrated on improving a (student) pilot’s anticipatory abilities (e.g., Talker, 2017) to successfully apply the knowledge and skills in time when faced with expected situations (Fornette et al., 2014). However, as accident reports revealed, a flight situation can rapidly change from “manageable” to “extremely challenging” if the safety-critical situation is unforeseen. The breakdown of anticipation might require a change from an automatic mental mode (= state of mind that is predominant in well-trained situations) to an adapted mental mode (essential in new, unforeseen situations) in order to respond flexibly and adequately to the changed conditions (Fornette et al., 2014). These additional cognitive processes, however, might pose the risk of losing valuable time in a life-threatening and highly time-critical situation (Burian, Barshi, & Dismukes, 2005; Fornette et al., 2014). In this regard, the study of Casner et al. (2013) revealed a significant increase in response times when pilots were faced with an abnormal in-flight event in unfamiliar cirmcumstances. Were these effects of an anticipation failure?

A main contributing factor to anticipation lapses can be seen in the increasing complexity of automated aircraft systems in the last decades (Landman et al., 2017). The increased pilot reliance on aircraft automation (European Aviation Safety Agency [EASA], 2017) and/or the less transparent flying process might increase the probability of a mismatch of the anticipated flight situation and the actual event. As recent studies revealed, a breakdown of anticipation may manifest itself in a considerable increase in emotional stress responses (Talker, 2017) and can negatively affect a pilot's performance (Casner et al., 2013; Landman et al., 2017).

How can pilots be cognitively trained in order to be prepared for the unexpected? Promising results from studies in a combat aviation population (Meland, Fonne, Wagstaff, & Pensgaard, 2015) revealed positive effects of cognitive adaptation training on concentration abilities as well as on arousal regulation. This new training approach is based on attention regulation and may overcome some limitations of previous training methods that are based on cognitive control (cf. Fornette et al., 2014).

But little is known about the impact of attention training on pilot performance and stress responses in unforeseen situations. Hence, the present study aims to elucidate to what extent attention training facilitates cognitive adaptation processes. These processes allow for the instantaneous adaptation to unforeseen safety-relevant changes in the environment and make use of the "on-line" mechanism of anticipation (i.e., closely related to the actual stimuli; Pezzulo, Butz, & Castelfranchi, 2008) in order to flexibly and appropriately respond to the current situational requirements, while keeping unnecessary stress activation low. In order to shed light on this issue, the effects of attention training on stress resilience and performance in unexpected flight situations will be experimentally examined in a FNPT-II simulator. Stress responses and performance will be assessed by collecting subjective data (performance ratings, questionnaires, and interviews), video and audio recordings of cockpit communication, and psychophysiological data (electrodermal activity).

Method

Participants

Twenty-four active pilots holding an Airline Transport Pilot Licence (ATPL) will be recruited for the study. They will not have to meet requirements in regard to a pilot's completed flying hours and the type rating a pilot holds. Each participant will take part in the experiment voluntarily. They will have to sign an informed consent and will be given the opportunity to quit the experiment whenever they wish, without giving any reasons. The participants will be naïve to the purpose of the experiment.

Design and Procedure

The study will comprise three main experimental phases (P): (I) training outside the flight simulator, (II) training in the simulator, and (III) the final simulator test. P I is scheduled for three months, P II and P III for about one hour, each.

Participants will be randomly assigned to two groups. In P I and P II, the experimental group (n = 12) will undergo an attention training, while the control group (n = 12) will do a muscle relaxation training in order to control for possible relaxing or restorative effects of the attention training procedure. Both groups will do the same final simulator test in P III where they will be faced with an unforeseen safety-critical flight situation.

The experiment will start with a 6-hour classroom seminar, performed separately for each group. The experimental group will be introduced to the theoretical background of attention training followed by the practical training session, where they will learn to deliberately regulate the allocation and the focus of attention. The practical training will include the following exercises (cf. Kabat-Zinn, 2003; Wagner, 2011; Williams & Kabat-Zinn, 2013): (1) Changing the focus of attention in the sense modalities seeing, hearing, and feeling, (2) Sitting upright with eyes closed with a "narrow" focus on the breath, and (3) sitting upright with eyes closed with a "broad" focus on thoughts, feelings, body sensations plus a "constant focus" on the breath. Participants will be instructed to observe arising sensations, thoughts, and feelings without judging them or wanting to change them. The exercises 1 and 2 will be for preliminary practice. The exercise 3 will be for further training outside the classroom (i.e., "home training"). The control group will be introduced to the theoretical background of relaxation followed by relaxation training in practice (Jacobson, 1934).

The participants of both groups will have to practice for 30 minutes three times a week, in a time frame of three months. Once a week, the participants will take part in a five-minute online one-to-one supervision session with the instructor where they will have the possibility to report their progress and to get support in case of problems.

After this training phase, the participants will undergo two simulator sessions – the simulator training and the final simulator test. The cockpit crew will consist of the pilot flying (= participant) and the copilot (= an experienced pilot who will be a member of the experimental team). The copilot will only take actions if instructed by the pilot flying.

Prior to the first simulator session, participants will have to complete the first questionnaire package. Thereafter, the electrodes for recording the participant's electrodermal activity (EDA) will be applied. EDA baseline measurements will be taken in an upright sitting position in the dark flight simulator cabin, with eyes closed. The simulation will be switched off during the baseline measurement.

Immediately before the simulator training, participants will do a 10-minute familiarization flight. In the simulator training phase, both groups will conduct an instruction flight. In order to simulate a real flight, the maneuvers will also include a takeoff and a landing procedure. At the beginning of each maneuver, the experimental group will be instructed to keep attention in the "here and now". The control group will will be instructed to keep their muscles relaxed.

After a break, where the participants will complete the second questionnaire package, both groups will undergo the final simulator test. Other than in the simulator training, the participants will not get any instructions in regard to attention or relaxation. Towards the end of the final simulator test, the participants will be faced with an unforeseen safety-critical situation. During the simulator test, video and audio recordings of the cockpit crew will be taken.

After the final simulator test, the third questionnaire package will be presented and the participants will attend a post-task reconstruction interview.

Apparatus

In order to fulfill the requirements of the planned study, a FNPT-II MCC (Flight and Navigation Procedures Trainer Type II Multi-Crew Co-operation) will be used. Offering a totally integrated system, the FNPT-II is fully instrumented for pilot and co-pilot stations. With a full autopilot capability, the autopilot can be controlled by either the pilot or the co-pilot (ELITE Simulations Solutions AG / S923 FNPT II MCC, 2021). The flight model of a Beech King Air B200 Twin Engine Turbine Aircraft will be used.

Dependent Variables

Performance will be assessed by using pre-defined criteria checked by a qualified instructor pilot. In order to evaluate different aspects of physical well-being, the Multidimensional Physical Symptom Check-List (MKSL – 24 – ak; Erdmann & Janke, 1978) will be used. The questionnaire includes 24 items which are aggregated into the four subscales: (1) nausea/cholinergic physical arousal, (2) adrenergic physical arousal, (3) pain, and (4) physical relaxation. Video and audio recordings in the cockpit during the final simulator test should reveal special aspects of a pariticipant's behaviour and his/her commands to the copilot. A post-task reconstruction interview after the simulator test will focus on the participant's perception of the unforseen situation as well as his/her thoughts, emotions, and self-described behavior before, during, and after the safety-critical situation. During both simulator sessions, electrodermal activity (EDA) will be recorded by using the method of exosomatic recording. Baseline measurements of 60 seconds will be taken at the beginning of each simulator session.

Statistical Analyses

Questionnaire data and EDA data will be analyzed using the procedure of mixed-design univariate ANOVAs with "group" as between-subject factor and "time" as within-subject factor. Independent samples t-tests (main effect of "group") and paired-samples t-tests (main effect of "time") will be used for post hoc analyses. In case of statistically significant "group" x "time" effects, post hoc analyses will be done by means of repeated-measures ANOVAs (and post hoc paired-samples t-tests) and by using independent samples t-tests. A significance level of $\alpha \leq .05$ will be adopted for the statistical tests. The assumption of normal distribution will be checked by means of the Kolmogorov-Smirnov Test, the premise of variance homogeneity will be evaluated by means of Levene Test, and the sphericity assumption will be evaluated by means of the Mauchly's Test. In case of violation, the Greenhouse-Geisser Test will be used in order to correct the degrees of freedom. Because of the explorative character of the study, no correction for type-I-error will be conducted.

EDA data (SCL, NS.SCRfreq) will be baseline-corrected and will be analyzed in three successive time intervals of 10 s, i.e., before, during and after the unforeseen situation (= "anticipation", "unforeseen effect", and "post effect").

Results

The main objective of the experiment is to reveal the effects of attention training, suspected to facilitate cognitive adaptation processes, on performance and stress responses in unexpected flight situations.

It is expected that the pilots trained in attention regulation will show lower emotional stress responses during the unexpected safety-critical situation, will get higher (i.e., better) performance ratings, and will show less decrements in physiological well-being after the final simulator test compared to the control group trained in relaxation techniques.

Discussion

Complex and unforeseen situations in flight can be extremely challenging even for experienced pilots and pose the risks of severe decrements in pilot performance (Casner, et al., 2013). For save pilot performance, anticipation of the near future is stressed to play a pivotal role (cf. SA, Endsley, 1995). Training approaches developed so far aim to improve anticipatory abilities (e.g., anticipation-based training, Talker, 2017) in order to facilitate anticipatory learning processes, suggested to build up strengthened mental representations of expected flight situations. However, these approaches might have limitations in case a pilot is faced with an unforeseen situation.

Current training approaches try to handle this problem by standardized trainings of abnormal events in the flight simulator. However, as Casner et al. (2013) could show, abnormal events become predictable when the flight scenarios are presented in the same sequence under the same circumstances. This procedure poses the risk of a low transfer of skills from training to the varying situations in the real flight environment. The question arises if a tested pilot really meets the requirements of an expert in managing abnormal and unforeseen events. An alarming answer has been provided by the findings of Casner et al., which revealed severe pilot performance decrements only in unfamiliar safety-critical flight situations in the simulator. These findings might reflect a breakdown of anticipation.

Does cognitive adaptation training based on attention provide an answer to this problem? It can be assumed that attention training facilitates cognitive processes which allow for the formation of continuously updated mental representations of the current flight situation. The proposed state of mind of being in the "here and now" (Kabat-Zinn, 2003; Williams & Kabat-Zinn, 2013) might play a key role in a pilot's ability to stay in immediate touch with the special aspects of the ongoing flight situation and might facilitate the "online-usage" of anticipation (Pezzulo et al., 2008). Because of the nonjudgmental attitude, attention training might also influence cognitive appraisal processes which might have positive effects on the occurrence of unnecessary emotional stress responses. The positive effects of attention training might manifest themselves as higher levels of stress resilience and as save pilot performance in unforseen flight situations.

Conclusions

Cognitive adaptation training based on attention might be a promising approach to improve flight safety – especially in complex and unforseen situations. Pilots trained to deliberately regulate their attention might have considerably improved skills for identifying safety-relevant cues from the flood of information and might be better equipped to flexibly and appropriately respond to unforeseeable safety-critical flight situations, while experencing low emotional stress responses.

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