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ENHANCING CREW RESOURCE MANAGEMENT TRAINING PROGRAM: THE INTRODUCTION OF A COGNITIVE-ADAPTATION TRAINING

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The goal of "crew resource management" (CRM) training programs is to enhance safety and efficiency in flight. To achieve this goal, CRM training have to teach the appropriate knowledge and skills, and thus, to be adjusted according to all environmental changes. During the last decade, there has been an increasing need to reinforce skills of French military crews, to deal with complex and unforeseen situations. A new cognitive-adaptation training was proposed. It specifically seeks to enhance metacognitive skills related to the two main types of human cognitive processes, and to strengthen reflective processes involved in cognitive and emotional adaptation. The effects of this training on adaptation skills and the relevance for the CRM courses of theoretical adaptation knowledge pertaining to this new training were evaluated. The results indicate that the new training may provide a useful tool for enhancing the ability of flying crews to manage complex and unforeseen situations.

To achieve high levels of safety and performance during flights, pilots need both technical and non-technical skills. For more than three decades, human factor (HF) training programs known as "crew resource management" (CRM) training have been used to teach non-technical skills to pilots. The goal of CRM training is to improve safety and efficiency in flight. The literature and aviation regulations provide recommendations on a set of core topics (e.g., communication, workload management, decision-making) which must be taught in CRM training. However, there is a great variability in what is trained during a CRM course (Salas, Wilson, Burke, & Wightman, 2006). In France, military-aviation CRM courses teach pilots general HF topics (e.g., communication, situation awareness, decision-making, fatigue), as well as more specific topics (e.g., different types of violations, military deployment, systemic safety). This is done through interactive training methods involving discussions regarding practical experiences by the participants.

To be effective, CRM training programs must be adjusted over time to remain relevant in a rapidly changing operational, organizational, and technical environment. New CRM training needs can be identified, on the one hand, through analyses of successful in-flight performance, and on the other hand, through the analysis of accidents, incidents or dysfunctions (O'Connor, Flin, & Fletcher, 2002). Such analyses can pinpoint CRM skills that need improvement through training. The topics included in French military-aviation CRM courses are based on an evaluation of needs which relies on, (a) observations and interviews of flying crews concerning their activities and HF difficulties, for the design of the CRM training, (b) evaluations of CRM training programs by the flying crews, after the training, and (c) analyses of changes in work conditions, over time. During the last decade, the French Air Force (FAF) was faced with an increasing number of constraints and changes due to the ever-increasing complexity and diversity of military operations and systems. In this context, operational task demands are likely to exceed the adaptation capabilities of military flight crews, and therefore, they are also likely to generate stress, to reduce performance, and to endanger air safety. An analysis of reports from the French Defense Air Accident Investigation Board reveals that some pilots were unable to use adequate adaptation skills to deal successfully with complex and unforeseen situations. Therefore, it seems especially important to enhance FAF CRM training programs with

specific knowledge and tools targeting adaptation to, and management of, complex and unforeseen situations. Accordingly, a new training that seeks to improve cognitive- and emotional-adaptation skills was proposed to the FAF. The new training was evaluated in a first study, which involved a sample of pilot cadets. In addition, for more than a year, theoretical knowledge pertaining to this new training has been included into CRM courses for the FAF.

In the following sections we, first, review relevant literature on cognitive and emotional adaptation, which provides the background for the new cognitive-adaptation training. We then describe the main principles of this new training, the main results that have been obtained in the first evaluation of the training in pilot cadets, and the recent introduction of adaptation knowledge into the CRM courses. Lastly, we discuss potential applications of the new training.

Cognitive and Emotional Adaptation

To maintain high levels of performance and safety in complex, unforeseen, and risky situations, pilots must be able to use adequate cognitive strategies and to manage their stress. HF experts have developed training programs that seek to enhance, on the one hand, cognitive adaptation, and on the other hand, stress management. Cognitive-adaptation training typically targets metacognitive skills, which involve a reflection on cognitive processes such as decision making or situation awareness. The most commonly used form of stress-management training in military aviation is based on the notion of *Stress Exposure Training* (SET). SET seeks to counter the effects of stress on performance through physiological, cognitive, or collective methods; however, it does not usually address the causes of stress.

To address the need to improve training in the management of complex and unforeseen situations, we decided to benefit from recent findings in neuropsychology and neuroscience which shed light on adaptation. In particular, we investigated research focusing on the relationships between cognition and emotion.

Cognitive Adaptation

Cognitive and behavioral adaptation in complex and dynamic situations is based on cognitive control, which involves the dynamic adjustment of cognitive processes to situational features such as environmental demands, as well as human features (e.g., aircraft failure, pilot's perceived workload; Hoc & Amalberti, 2007). Continuous cognitive control allows pilots to adjust performance to changing situations, so as to maintain adequate efficiency and avoid excessive fatigue. In cognitive psychology, human cognition is usually modeled as a juxtaposition of two complementary types of cognitive processes (for review, see Evans & Frankish, 2009). The first type of cognitive processes, which are referred to as *automatic processes*, is usually involved primarily in the management of simple and well-known situations by using learned action strategies or innately programmed behaviors. The second type of cognitive processes, which are also referred to as *reflective processes,* relates to abstract reasoning, hypothetical thinking, and cognitive flexibility, which are involved in intervening on, or overriding of, default, automatic processes. Reflective processes play an important role in the management of complex and unknown situations via the formation of new, adaptive, and creative cognitive strategies, and they allow the individual to anticipate future events.

Emotion Regulation

In military operations, stress is obviously an important issue, which is related to the broader topic of emotion regulation. Three types of intentional emotion-regulation strategies are described in the literature: (a) avoidance of emotionally meaningful stimuli, (b) modulation of emotional responses, and (c) cognitive change or reappraisal, which involves changing how we think about a situation (Gross, 2002). Cognitive change appears to be one of the most effective strategies (Butler, Chapman, Forman, & Beck, 2006; Gross & John, 2003), presumably because it addresses directly the cause of emotions. It is largely used in cognitive-behavioral therapy through metacognitive techniques such as cognitive restructuring, which seek to improve access to more adaptive modes of thinking, or representations of events that trigger stress.

Relationships between Cognitive and Emotional Adaptation

In recent years, several studies have investigated the relationship between cognitive processes and emotion regulation (e.g, Compton et al., 2011; Ochsner & Gross, 2005). Functional imaging studies have revealed that cognitive change techniques can reduce emotional disturbance by inhibiting automatic bottom-up processes while

strengthening reflective top-down processes in patients as well as in healthy individuals (e.g., Clark & Beck, 2010). Therefore, the awareness of, and self-adjustment to, one's own cognitive processes and representations appear to occupy a central place in both cognitive and emotional adaptation.

Neuropsychological studies focusing on adaptation disorders are consistent with this view. The neuropsychological concept of executive functioning shares several aspects with reflective processes. Executive functioning is described as: (a) facilitating adaptation when the novelty or complexity of a given situation precludes an automatic response, and (b) involving in emotion regulation by relying on higher-level cognitive processes (Suchy, 2009). Reflective (or executive-functioning) processes are likely essential for efficient self-regulation of cognition and emotion in complex or unforeseen situations.

A New Cognitive-Adaptation Training

Accordingly, we decided to propose a new training that seeks to enhance metacognitive skills related to the two previously mentioned types of human cognitive processes, and to strengthen reflective processes implied in cognitive and emotional adaptation.

Principles of the New Cognitive-Adaptation Training

This cognitive-adaptation training called *Mental Mode Management* (Fradin, Aalberse, Gaspar, Lefrançois, & Le Moullec, 2008; Fradin, Lefrançois, & El Massioui, 2006) is based on the Cognitive-Processes Scale (CPS). This scale provides a description of automatic processes (hereafter referred to as *automatic mental mode*), and of reflective processes (hereafter referred to as *adaptive mental mode*). Each mental mode is described using six dimensions (see Table 1). CPS is a pedagogic self-report tool, which consists of seven Likert-type scales, including six scales that are used to assess mental mode or frame of mind, and one scale used to assess stress. For example, the first scale allows individuals to evaluate whether they are approaching a situation as if it were routine (i.e., known and mastered), or with a curious frame of mind; the third scale is used to evaluate whether, in a given situation, the individual tends to think of "black and white", or in a more nuanced way. The training consists in:

1. choosing a stressful or difficult-to-adapt-to situation,
2. becoming (more) aware of the predominant frame of mind (or mental mode) and stress experience during that situation, using imagined confrontation and the CPS,
3. practicing (a) mental mode management (MMM) technique(s) to reinforce adaptive mental mode,
4. evaluating again the mental mode and stress experience in the chosen situation using CPS, to assess the (possible) difference pre-to-post practice and then the efficiency level of MMM technique(s).

MMM techniques are mainly reflexive. One of the most global techniques to promote the adaptive mental mode consists in asking oneself questions without providing immediate answers, for the six dimensions of this mental mode. Two example questions for the dimensions "logical reasoning" and "individual opinion" are: "How would it work if I looked at the situation in terms of causes and effects?" and "If I put aside the judgment of the others and I think about what is really at stake for me, what do I personally think? ", respectively (for more information about MMM techniques, see Fornette et al., 2012; Fradin, 2003; Fradin et al., 2008).

Table 1.

Dimensions of Automatic Mental Mode and of Adaptive Mental Mode.

Automatic Mental Mode	Adaptive Mental Mode
Routine	Curiosity
Refusal	Acceptance
Dichotomy	Nuance
Certainty	Relativity
Priority to results	Logical reasoning
Social image	Individual opinion

Effects of the New Training on Performance and Stress Management

A first evaluation of MMM training effects on flight performance and stress management was carried out in a sample of FAF pilot cadets. The main methodological features and results of this study may be summarized as follows (for additional information see: Fornette et al., 2012).

The class of pilot cadets ($N = 21$) was divided into two groups: a Training Group (TG), which participated in six two-hour training sessions, and a Control Group (CG), which did not receive training. Both groups were balanced with respect to emotional profiles, initial performance, and instruction-squadron membership. Within each group, cadets were further divided into two subgroups (High- and Low-performance level) based on the median score of the class. This resulted in four subgroups: TG-Low, TG-High, CG-Low, and CG-High. In-flight performance (in the form of scores ranging from 0 to 20, which were assigned by flight instructors) was measured; so were mood, anxiety, and stress-management mode, using questionnaires (POMS, STAI-Y-A, and specific questionnaires, respectively).

A comparison between in-flight performance before and after training showed a significant improvement ($p \leq .05$) for the lowest-ranked cadets in the training group (TG-Low). For the three other subgroups, no significant change was observed. Pre- and post-training flight score means of the four subgroups are shown in Table 2. The improvement for the TG-Low group persisted until the end of the basic flying program (i.e., 1.5 months after the end of the training). Mood and anxiety scores did not differ significantly between the training and control groups. However, the number of cadets who reported having changed their mode of stress management during the study was significantly higher ($p \leq .05$) for the training group (80%) than for the control group (27%). Moreover, 70% of the training group cadets stated that the cognitive-adaptation training had allowed them to better understand events and, consequently, to reduce their stress level.

Table 2.
Flight Score Means and Standard Deviations for the Low- and High-Level Subgroups of the Training and Control Groups During the Pre-training and Post-training Phases.

		Phase			
		Pre-training		Post-training	
Subgroup	*n*	*M*	*SD*	*M*	*SD*
TG-Low (Training Group - Low Level)	6	13.33	0.67	14.18	0.53
TG-High (Training Group - High Level)	4	14.03	1.01	13.65	0.67
CG-Low (Control Group - Low Level)	5	13.55	0.83	13.43	0.41
CG-High (Control Group - High Level)	6	14.34	0.66	14.33	0.59

Relevance of Theoretical Knowledge Pertaining to the New Training, for the CRM Courses

Knowledge concerning reflective processes and their involvement in cognitive and emotional adaptation has been inserted in introductory or refresher CRM courses in the FAF for over a year now. Such knowledge has been used to revise the "Stress management" topic of the CRM course, and to include a new topic called "Management of complexity and of the unforeseen". The impacts of these revised and new topics were evaluated using four criteria and a four-point Likert scale (see Table 3). This is some of the usual evaluation of CRM topics which takes place just after the training. Although they are still preliminary, the results of this evaluation indicate that the inclusion into CRM courses of knowledge concerning cognitive and emotional adaptation enhances HF knowledge and provides flying crews with a new, richer, view of their own activities. The evaluation of the impact on the change of practices is also satisfactory, although, so far, only theoretical knowledge concerning adaptation has been introduced into CRM courses. This contribution to the change of practices should be further improved because MMM techniques will likely be included in future refresher CRM courses.

Table 3.
Percentage of responses "*Not at all*", "*Rather no*", "*Rather yes*", "*Definitely yes*" *for the four evaluation criteria corresponding to the CRM topics:* "*Stress management*" *and* "*Management of complexity and of the unforeseen*".

Criterion: Is the topic useful to…?	Not at all	Rather no	Rather yes	Definitely yes
1. becoming aware of the scope of FH dimensions	0.5 %	1 %	47 %	51.5 %
2. learning of new FH knowledge	0 %	0 %	27 %	73 %
3. promoting useful discussions	0.5 %	0.5 %	34 %	65 %
4. helping change practices	0.5 %	7 %	36.5 %	56 %

Conclusion

Although the evaluation carried out in pilot cadets remains limited, and the introduction in the CRM courses is relatively recent, the results suggest that the new cognitive-adaptation training has the potential to benefit cognitive and emotional adaptation skills. These results, if they are confirmed in future studies, would support the view that cognitive-adaptation training programs that seek to promote the use of reflective processes may provide a useful pedagogical tool for enhancing both cognitive and emotional adaptation in flying personnel, and ultimately, for improving flight safety.

The metacognitive skills acquired through this training on general adaptation skills can be generalized and transferred, which could be especially advantageous in risky and ever-changing occupational settings. Therefore, the principles of this cognitive-adaptation training could be used to supplement training programs that seek to improve situation awareness, decision making, stress management, and more generally, the management of complex and unforeseen situations, in various fields and for different operators' profiles (from novice to expert).

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