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Background. Mnemonic procedures are currently being taught to airline pilots to manage startle and surprise. We previously tested the effectiveness of a four-item mnemonic. Pilots generally rated it as useful but some remarked that it induced too much additional workload. Therefore, we tested whether a simpler mnemonic, Aviate-Breathe-Check, would be more useful. **Method.** The experiment took place in a hexapod simulator with a Piper Seneca aerodynamic model and a generic cockpit. Airline pilots (n = 25) were divided into an experimental ("ABC") and control group. All received ground training on startle and surprise, which included instructions on the ABC mnemonic for the ABC group. The mnemonic aims to support prioritization of flight-path management (Aviate), followed by physiological and mental stress management (Breathe), followed by troubleshooting (Check). All pilots performed four familiarization scenarios, during which the ABC group practiced the ABC mnemonic. Two test scenarios were then performed to evaluate performance, mental effort, stress, and pilot evaluations of the ABC mnemonic. **Results.** The pilots' evaluations of the ABC mnemonic were significantly higher than those were for the previously-tested mnemonic in the same scenarios. There were no significant differences between the ABC and control group in mental effort and stress, whereas there were trends towards higher mental effort and stress with the previous mnemonic. No significant effects on performance were found. **Conclusions.** The results suggest that the ABC mnemonic was more useful and easier to apply than a previously tested mnemonic. This is promising for the development of effective pilot training interventions for startle and surprise.

Startle and surprise have the potential to seriously impair pilots' abilities of troubleshooting and immediate procedural responses (Landman, Groen, Van Paassen, Bronkhorst, & Mulder, 2017b). "Startle" refers to a stress response to a sudden intense stimulus, whereas "surprise" is an emotional and cognitive response indicating a mismatch between expectation and reality (Landman, Groen, Van Paassen, Bronkhorst, & Mulder, 2017a). Dealing with an unexpected event may require "reframing" of the situation, meaning that the situation is analysed and the cognitive mismatch is resolved. This process is thought to be especially difficult to perform if the above-mentioned cognitive functions are impaired by stress (Landman et al., 2017a; Eysenck & Derakshan, 2011). Startle and surprise may thus have an interactive negative effect on performance, and can lead to pilots remaining "stuck" in this impaired state if the failures to reframe increase stress even further.

Startle and surprise management has been increasingly incorporated in (recurrent) pilot training (European Aviation Safety Authority, 2015; Federal Aviation Administration, 2015). However, empirical data on effective startle and surprise management training are still lacking. One type of training intervention that has been proposed is to teach pilots a short startle and surprise management procedure. This consists of one or more actions which could be useful for managing the effects of stress, facilitating the reframing process, or both. Examples of these actions are, in sequential order: 1) performing a stress reduction technique like taking a deep breath or releasing muscle tension (Field, Boland, Van Rooij, Mohrmann, & Smeltink, 2018; Landman et al., 2020; Martin, 2017), obtaining situation awareness with regard to available time (Gillen, 2016), primary flight parameters, (Landman et al., 2020; Gillen, 2016) and indications of the problem, (Martin, 2017; Landman et al., 2020; Field et al., 2018), or taking decisive action (Martin, 2017; Field et al., 2018; Landman et al., 2020). These actions are usually taught in the form of a mnemonic, which makes them easy to remember and apply in the appropriate order.

The effectiveness of such a mnemonic procedure was recently tested in a simulator experiment (Landman et al., 2020). The procedure was taught using the mnemonic *COOL*, with the steps *Calm down*: take a deep breath, sit up straight, release muscle tension in shoulders and arms, focus on exerted force on the controls *Observe*: check and call out primary flight parameters, *Outline*: focus on the problem and analyze it, and *Lead*: formulate a plan and act. Pilots in the experiment generally found the method useful. Results also indicated that the method led to better analysing of the problem as pilots were more likely to take actions to prevent exacerbation. However, there were also non-significant trends and anecdotal remarks by pilots indicating that the mnemonic procedure was too mentally demanding, and distracted from giving priority to crucial actions (e.g., recovering an upset).

Thus, the current study is aimed to test the effectiveness of a new mnemonic procedure that is shorter, more simple, and includes prioritization of restoring the flight path. This procedure was *ABC* with the steps: *Aviate*: ensure that the flight path is stabilized, *Breathe*: the same as *Calm down* in *COOL*, *Check*: the same as *Observe* in *COOL* with the difference of not having to call out instrument readings.

Method

Participants

The sample group consisted of 25 commercial airline pilots, who were assigned to an experimental group (ABC, n = 13) or control group (n = 12). Characteristics of the groups are listed in Table 1. Despite efforts to balance the groups, an independent-samples t test indicated that the ABC group scored significantly higher than control on trait anxiety as measured with the State-Trait anxiety index (Spielberger, Gonzalez-Reigosa, Martinez-Urrutia, Natalicio, & Natalicio, 1971), $p = 0.008$. There were no other significant or nearly significant differences between groups.

Table 1
Characteristics of the participants.

	ABC	Control
Age in years (mean, SD)	41.0, 9.9	44.5, 8.3
Flight hours large transport (mean, SD)	9,750 (6,899)	10,160 (5,732)
Working experience in years (mean, SD)	17.6 (11.2)	14.0 (9.5)
Trait anxiety score range 20-80 (mean, SD)	31.4 (5.3)	26.7 (3.3)
Captains / FOs / SOs*	6/6/1	7/4/1
Type rating instructors or examiners	2	1
Men / Women	11/2	12/0

Apparatus

The experiment was performed using the SIMONA research simulator located at the Delft University of Technology. This is a full motion flight simulator featuring six hydraulic actuators, and allowing pilots a 180 degrees field of view. One projector malfunctioned during the experiment, resulting in a field of view of 120 degrees instead. The cockpit mock-up and aerodynamic model were based on the Piper Seneca PA-34, a multi-engine piston aircraft. All participating pilots had flown a similar type during their initial training. Controls consisted of a column with electric pitch trim, rudder pedals, throttle, flaps, and gear. The left seat was used, see Fig. 1.

Figure 1. The experimental setup (left seat).

Procedure

The experimental procedure was very similar to (Landman et al., 2020). Both the ABC and control group received familiarization with the simulator and a briefing on startle and surprise to prevent differences in expectations between groups. The ABC group received an explanation of and instruction to use the "ABC" procedure (see Introduction). They were told that the goals of the procedure were to support proper prioritization of actions, and recognize and manage psychological and physiological effects of startle and surprise. Both groups then performed four training scenarios with non-normal events so that the ABC group could practice the *ABC* procedure. Finally, both groups performed two test scenarios: the Cargo Shift scenario in which cargo shifted towards the tail during take-off, and the Flap Asymmetry scenario which occurred at base leg (see Landman et al., 2020). Pilots had no checklists for these failures. Both failures required timely control responses and a quick analysis of the limited controllability. Both issues also allowed for making the decision to land with partial flaps or flaps up to prevent further exacerbation of controllability problems.

Dependent measures

Immediately after each test scenario, pilots rated perceived mental effort experienced during the scenario on the Rating Scale for Mental Effort (RSME) (Zijlstra, 1995), and perceived stress on a 1-10 point Likert scale (Houtman & Bakker, 1989). Baseline measures of stress and mental effort were also obtained in the last familiarization scenario. These were subtracted from the measures in the test scenarios to correct for individual differences. Perceived startle and surprise were both rated on custom scales similar to the one used for stress. This was done to check if the scenarios succeeded in startling and surprising the pilots. The ABC group rated perceived usefulness of the procedure after the test scenarios on a 1-10 point Likert scale. As a measure of performance, the decision to divert from the normal flaps LAND setting in each scenario was used as a binary measure. Using flaps LAND following the failure would severely reduce controllability in each scenario.

Statistical analysis

The baseline-corrected mental effort and stress scores were compared between the ABC and control group using Mann Whitney U tests, which is a non-parametric between-subjects test. Perceived usefulness ratings were compared using the same test between the ABC group and data of the COOL group obtained in the same scenarios from a previous study (Landman et al., 2020). Decisions to divert from normal flap settings were compared between groups using a Pearson Chi-squared test.

Results

Two participants of the ABC group were excluded from the Flap Asymmetry analysis due to either not noticing the failure or due to noticing the failure too late for a response.

No significant differences were found between ABC and control on perceived mental effort and stress (see Table 2. On average, the Flap Asymmetry scenario was rated 4.7 (SD = 2.1) on startle, 5.6 (SD = 2.2) on surprise, 61.3 (SD = 19.7) on mental effort, and 4.0 (SD = 2.0) on stress. The Cargo Shift scenario was rated on average 6.6 (SD = 2.1) on startle, 7.2 (SD = 1.7) on surprise, 75.0 (SD = 21.3) on mental effort and 5.6 (SD = 2.1) on stress.

In the Flap Asymmetry scenario, we observed 6/11 pilots in the ABC group and 5/12 pilots in the control group select flaps LAND, with 4/11 and 3/12 also landing with this

Table 2
Change from baseline to the post-test scenarios in perceived mental effort and stress.

	ABC Mean (*SD*)	Control Mean (*SD*)	*p*
Flap Asymmetry scenario			
Δ Mental effort (1-150)	8.3 (23.0)	10.6 (12.4)	0.688
Δ Stress (1-10)	1.3 (1.9)	1.1 (2.0)	0.640
Cargo Shift scenario			
Δ Mental effort (1-150)	21.4 (28.8)	25.6 (16.7)	0.479
Δ Stress (1-10)	3.5 (2.8)	2.6 (1.4)	0.614

setting, respectively. In the Cargo Shift scenario, we observed 2/13 pilots in the ABC group and 5/12 pilots in the control group selecting flaps LAND, with 2/13 and 3/13 also landing with this setting, respectively. There were no significant differences between groups.

Perceived usefulness of the method was significantly higher in ABC, mean = 7.0, *SD* = 0.8, than COOL, mean = 5.2, *SD* = 1.8, in the Cargo Shift scenario, $p = 0.004$, but not in the Flap Asymmetry scenario, $p = 0.814$.

Discussion

The ABC procedure did not have a significant effect on pilots' perceived mental effort, stress and performance in the scenarios. Whereas a previous experiment indicated a trend towards more mental workload when using the COOL procedure than control, no such trends were observed in the current study.

The perceived usefulness of the ABC procedure was scored significantly higher than the COOL procedure was scored by a different sample group (Landman et al., 2020). This was only the case in the Cargo Shift scenario, which requires an immediate response to recover a pitch up upset. This recovery was not easy, as the backwards shifting of the center of gravity reduced authority in the pitch axis, and in some cases required roll and throttle changes to prevent loss of control. After recovering, pilots were seen to test the effect of pitch control inputs to get themselves acquainted with the changed dynamics. Thus, the step *Aviate* of the ABC procedure could help pilots in this scenario to focus on regaining and ensuring stability and control in this scenario. A second reason why the procedure was possibly most effective in the Cargo Shift scenario is that this scenario was also rated as the most startling and stressful scenario. The Flap Asymmetry scenario was moderately successful in inducing startle and surprise in pilots, as subjective ratings of startle, surprise, stress and mental effort were around the midpoints of the scale. The Cargo Shift scenario was more successful, as scores were above the midpoint of the scales.

One limitation is that the ABC group scored significantly higher on trait anxiety than the control group, which may have caused the ABC group to respond with relatively more stress to the scenario events. A second limitation is that the experiment featured a simple aircraft model with scenarios that did not involve crew resource management or complex system failures. Whether the effects also translate to large transport aircraft operations is not certain.

Remarks by pilots suggested that parts of the procedure could be selected based on the situation at hand. Some preferred calling out the steps, whereas others preferred not to. Calling out either out loud or in one's mind of (one of) the steps, such as "Aviate", or a different calming phrase, could be an effective self-talk method for managing stress (Tod, Hardy, & Oliver, 2011). Future research could focus on the effectiveness of such self-talk, and on the usefulness of startle management procedures in varying types of startling situations. The results suggest that brevity and simplicity are important aspects of an effective startle and surprise management procedure.

References

European Aviation Safety Authority. (2015). Loss of control prevention and recovery training (notice of proposed amendment 2015-13).

Eysenck, M. W., & Derakshan, N. (2011). New perspectives in attentional control theory. *Personality and Individual Differences*, *50*(7), 955–960.

Federal Aviation Administration. (2015). Stall prevention and recovery training. *(Advisory Circular No. 120-109A).*

Field, J. N., Boland, E. J., Van Rooij, J. M., Mohrmann, F. W., & Smeltink, J. W. (2018). *Startle effect management. (report nr. NLR-CR-2018-242)* (Tech. Rep.).

Gillen, M. W. (2016). *A study evaluating if targeted training for startle effect can improve pilot reactions in handling unexpected situations in a flight simulator.* The University of North Dakota.

Houtman, I., & Bakker, F. (1989). The anxiety thermometer: a validation study. *Journal of personality assessment*, *53*(3), 575–582.

Landman, A., Groen, E. L., Van Paassen, M. M., Bronkhorst, A. W., & Mulder, M. (2017a). Dealing with unexpected events on the flight deck: A conceptual model of startle and surprise. *Human factors*, *59*(8), 1161–1172.

Landman, A., Groen, E. L., Van Paassen, M. M., Bronkhorst, A. W., & Mulder, M. (2017b). The influence of surprise on upset recovery performance in airline pilots. *The International Journal of Aerospace Psychology*, *27*(1-2), 2–14.

Landman, A., van Middelaar, S. H., Groen, E. L., van Paassen, M. M., Bronkhorst, A. W., & Mulder, M. (2020). The effectiveness of a mnemonic-type startle and surprise management procedure for pilots. *The International Journal of Aerospace Psychology*, *30*(3-4), 104–118.

Martin, W. (2017). *Developing startle and surprise training interventions for airline training programs.* https://pacdeff.com/wp-content/uploads/2017/08/PACDEFF-FC-Forum-Presentation-on-Startle.pdf.

Spielberger, C. D., Gonzalez-Reigosa, F., Martinez-Urrutia, A., Natalicio, L. F., & Natalicio, D. S. (1971). The state-trait anxiety inventory. *Revista Interamericana de Psicologia/Interamerican journal of psychology*, *5*(3 & 4).

Tod, D., Hardy, J., & Oliver, E. (2011). Effects of self-talk: A systematic review. *Journal of Sport and Exercise Psychology*, *33*(5), 666–687.

Zijlstra, F. R. H. (1995). Efficiency in work behaviour: A design approach for modern tools.