References

1. Boulet J, van Zanten M. Ensuring high-quality patient care: the role of accreditation, licensure, specialty certification and revalidation in medicine. *Med Educ* 2014; **48**: 75–86
2. Jonker G, Manders LA, Marty AP, et al. Variations in assessment and certification in postgraduate anaesthesia training: a European survey. *Br J Anaesth* 2017; **119**: 1009–14
3. Watling CJ, Lingard L. Grounded theory in medical education research: AMEE Guide No. 70. *Med Teach* 2012; **34**: 850–61
4. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. *Acad Med* 2014; **89**: 1245–51
5. Cooper WO, Spain DA, Guillamondegui O, et al. Association of coworker reports about unprofessional behavior by surgeons with surgical complications in their patients. *JAMA Surg* 2019; **154**: 828–34

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Impact of stress management strategies and experience on electrodermal activity during high-fidelity simulation of critical situations

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Initial results of this study were presented at the 2019 annual meeting of the Society for Neuroscience, Chicago, IL, USA, November 2019 and at the 1st International Conference for Multi-Area Simulation, Angers, France, October 2019.

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Editor—Acute stress has been shown to decrease performance of cognitive tasks. Health professionals are often required to make cognitive decisions during stressful situations. Residents trained in stress management strategies (tactics to optimise potential [TOP]) show improved performance when coping with critical situations during high-fidelity simulation (HFS).[1] Performance enhancement might result from the effect of TOP on stress regulation, leading to a more controlled biological stress reaction or balanced arousal with the subject being better prepared for action. Separating electrodermal activity (EDA) into its tonic (i.e. slow variation) and phasic (i.e. fast variation) components identifies the arousal phenomenon and sympathetic nervous system activity.[2] These EDA components are under the influence of two neuroanatomical networks.[3] The tonic component is influenced by the orbitofrontal and ventromedial prefrontal cortices, whilst the phasic component is influenced by various brain areas, including the thalamus, hypothalamus, striate and extra-striate cortices, anterior cingulate and insular cortices, and some lateral regions of the prefrontal cortex.[3] Both are mobilised during stress: tonic EDA increases, whilst the phasic EDA bursts increase in both amplitude and frequency.[4] Both stress dimensions were better controlled in senior residents, indicating that experience reduces perceived stress.[5] As TOP decreases perceived stress in residents,[1] we wanted to explore the impact of TOP on the EDA components.

The effect of TOP on the performance of 128 anaesthesia residents facing a critical situation in HFS was studied in a prospective RCT.[1] Assessment of the mechanism of action of

TOP through EDA analysis was an ancillary objective. The study protocol was pre-registered on October 6, 2016 on ClinicalTrials.gov (NCT02926599) and was approved by the Institutional Review Board of the Comité de Protection des Personnes SUD-EST II (2016-089).

Residents received general information about the study and then gave their written individual informed consent. They were randomised into two parallel arms: TOP or control. The TOP training consisted of five 60 min sequences given once a week for five consecutive weeks by two instructors and ending 1 month before the high-fidelity simulation. TOP consist of techniques, such as mental imagery, cardiac coherence biofeedback, and sensory relaxation.[6] In our study, TOP was focused on breathing control using relaxing and revitalising breathing techniques and on optimisation of readiness through mental rehearsal of the upcoming actions (Supplementary material 1.A). The control group did not have any training. Senior residents were defined as those having responsibility for on-call duty (which in France means >3 yr experience).

On the day of the high-fidelity simulation, participants were equipped with a wristband measuring device (E4 Empatica Srl, Milan, Italy) on their dominant hand for continuous measurements of EDA at a sampling rate of 4 Hz. The high-fidelity simulation was explained to the participants (briefing). The TOP group participants were then asked to sit down and perform the previously learned TOP exercises for 5 min (Supplementary material 1.B), whilst the control group participants only read laboratory test results. Thereafter, all participants did one critical simulated scenario followed by a debriefing. EDA was measured over four distinct time periods: briefing, intervention, scenario, and debriefing. We considered that 93 out of the 128 participants had complete EDA recordings, whilst the remainder had incomplete recordings because of technical problems.

EDA was normalised using the z-score. Its phasic and tonic components were extracted using a validated convex optimisation algorithm that defines EDA as the sum of a tonic, phasic, and noise component.[2] This algorithm solves EDA deconstruction by a quadratic optimisation approach.[2] The mean tonic EDA (mtEDA) and the maximum phasic EDA (mapEDA) were calculated for each subject during each period of the high-fidelity simulation. Statistical analysis was performed using analysis of variance for repeated measures comparing conditioning (TOP [n=43] or control [n=50]) and experience (junior [<3 yr; n=47] or senior [≥3 yr; n=46]). The interaction conditioning*experience corresponded to the combined effects of the TOP and experience. The statistical threshold was set at $P<0.05$, and *post hoc* Bonferroni tests for all pairs were performed if necessary.

The mtEDA showed a significant experience effect (F[3267]=4.12; $P<0.01$) unrelated to conditioning. *Post hoc* analysis showed that seniors exhibited a lower mtEDA than juniors during the scenario and debriefing periods ($P<0.01$ and $P<0.05$, respectively; Fig. 1a). The mapEDA showed a significant intervention effect (F[3267]=3.45; $P<0.05$) without an experience effect or any interaction. Compared with the control participants, the TOP participants did not have a mapEDA increase during the intervention or other periods (Fig. 1b). During the debriefing, the mapEDA of control participants was higher than that of control and TOP participants during intervention ($P<0.001$ and $P<0.05$, respectively).

Depending on which component is considered, EDA may also indicate the brain networks involved. Experience has a major effect on the tonic EDA. Senior residents had a lower sympathetic tone than juniors. Moreover, seniors, in contrast to juniors, did not experience an increase of tonic EDA during the scenario. Thus, experience may modulate the orbitofrontal and ventromedial prefrontal cortices in agreement with the known role of the ventromedial prefrontal cortex in coding the latent structures of experience, the causal links, and the task-related cognitive maps.[7] The mapEDA is a reliable marker of sympathetic activity,[2] which has been reported to increase in residents practising high-fidelity simulation.[8] As the mapEDA was steady in TOP participants but not in controls during the simulation scenario,[1] it appears that TOP contributes to stress

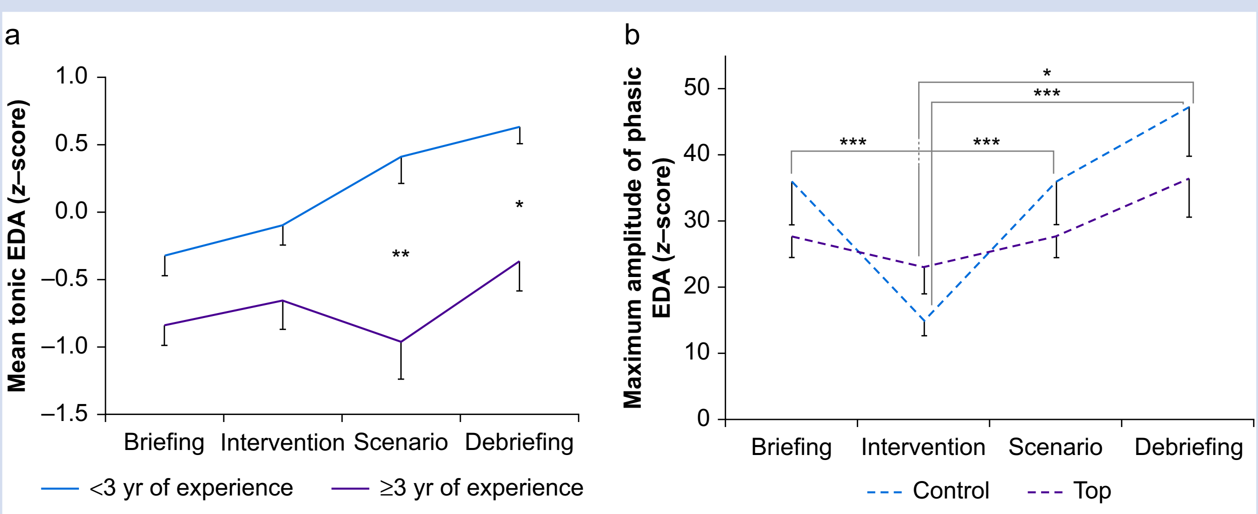

Fig 1. (a) Mean tonic electrodermal activity (EDA) in function of experiment periods and of years of training group. Results are expressed as means (standard error of the mean [SEM]). *$P<0.05$; **$P<0.01$ to Bonferroni test. (b) Maximum amplitude of phasic EDA in function of experiment periods and of treatment group. Results are expressed as means (SEM). *$P<0.05$; ***$P<0.001$ to Bonferroni test. TOP, tactics to optimise potential.

regulation and reduced sympathetic activation. This is in agreement with the decreased subjective feeling of stress in TOP participants.[1] Furthermore, the better regulation of phasic EDA in TOP participants reinforces the concept of down-regulation of the amygdala observed with functional MRI after other cognitive therapy,[9] as the amygdala, part of the limbic system, controls the phasic component of the sympathetic nervous system.[10]

Using the components of EDA, we show for the first time that experience and stress management strategies may modulate two different pathways controlling the stress reaction.

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Declarations of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2020.07.024.

References

1. Sigwalt F, Petit G, Evain J-N, et al. Stress management training improves overall performance during critical simulated situations: a prospective randomized controlled trial. *Anesthesiology* 2020; **133**: 198–211
2. Greco A, Valenza G, Lanata A, Scilingo EP, Citi L. cvxEDA: a convex optimization approach to electrodermal activity processing. *IEEE Trans Biomed Eng* 2016; **63**: 797–804
3. Nagai Y, Critchley HD, Featherstone E, Trimble MR, Dolan RJ. Activity in ventromedial prefrontal cortex covaries with sympathetic skin conductance level: a physiological account of a "default mode" of brain function. *Neuroimage* 2004; **22**: 243–51
4. McNeal KS, Spry JM, Mitra R, Tipton JL. Measuring student engagement, knowledge, and perceptions of climate change in an introductory environmental geology course. *J Geosci Educ* 2014; **62**: 655–67
5. Abdulghani HM, Al-Harbi MM, Irshad M. Stress and its association with working efficiency of junior doctors during three postgraduate residency training programs. *Neuropsychiatr Dis Treat* 2015; **11**: 3023–9
6. Trousselard M, Dutheil F, Ferrer M-H, Babouraj N, Canini F. Tactics to optimize the potential and CardioBioFeedback in stress management: the French experience. *Med Acupunct* 2015; **27**: 367–75
7. Mack ML, Preston AR, Love BC. Ventromedial prefrontal cortex compression during concept learning. *Nat Commun* 2020; **11**: 46
8. Phitayakorn R, Minehart RD, Hemingway MW, Pian-Smith MCM, Petrusa E. Relationship between physiologic and psychological measures of autonomic activation in operating room teams during a simulated airway emergency. *Am J Surg* 2015; **209**: 86–92
9. Gingnell M, Frick A, Engman J, et al. Combining escitalopram and cognitive-behavioural therapy for social anxiety disorder: randomised controlled fMRI trial. *Br J Psychiatry* 2016; **209**: 229–35
10. Sinha GR, Suri JS. *Cognitive informatics, computer modelling, and cognitive science: volume 2: application to neural engineering, robotics, and STEM*. London: Elsevier; 2020

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Brachial plexus blockade with anomalous location of the T1 ventral ramus at the supraclavicular fossa

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