Table II. Physiological Measures That Can be Extracted from NIRS Sensing.<sup>2</sup>

SYSTEM	MEASURE	INDICATION
Cardiopulmonary	Heart rate, heart rate variability	Hypoxia, dehydration, stress, anxiety
Hemodynamic Response	Cerebral blood flow velocity, blood oxygenation	Workload, attention, hypoxia, dehydration
Respiration	Respiratory rate	Hypoxia, anxiety
Brain Activity	Spatial and temporal information about brain activation	Arousal, workload, attention, hypoxia, dehydration

Not only must this potential operational fNIRS system address the cognitive and physiological multistate assessment previously mentioned, but an operational fNIRS system must also solve problems with sensor placement, movement artifacts, and environmental impacts to data quality (e.g., sunlight). Although there are many signal processing and analysis approaches that can be used to clean data signals, there is no substitute for clean data, and such methods often require significant computational resources for online operation. The form factor of the hardware has a significant impact on the signal quality and is generally the biggest challenge preventing the use of fNIRS in operational environments<sup>5</sup>. The primary sources of noise impacting the collection of fNIRS signals are: 1) motion of the light source and optodes, which causes disruption or fluctuation in the signal detected; and 2) individual differences in skin tone, hair color, and head shape, which cause variations in the quality of signal. These challenges can be addressed in the form factor of the design, placement of sensors, noise attenuation strategies, and, when necessary, machine learning or autopreprocessing of data.

As indicated by Adamovsky et al.,<sup>1</sup> there is a need for an operational fNIRS system that satisfies the constraints typically faced in applied settings. Fortunately, the Defense Health Agency recently awarded a new Small Business Technology Transfer grant (DHA STTR 19B-001) to support the development of such a system. Performers on this project will explore the viability of an operational aerospace fNIRS system by evaluating form fit, sensors, data cleaning and processing, and multistate detection as outlined in this article. Furthermore, advanced techniques like hyperscanning and neurofeedback will be considered for their applicability in an aerospace environment for activities involving training, crew planning, flight performance, and many other potential areas of interest that are yet to be determined.

## REFERENCES

- Adamovsky G, Mackey JR, Harrivel A, Hearn TA, Floyd BM. Toward adaptation of fNIRS instrumentation to airborne environments. In: AIAA Infotech@Aerospace (I@A) Conference. August 19–22, 2013; Boston, MA. AIAA 2013-4895.
- Adan A. Cognitive performance and dehydration. J Am Coll Nutr. 2012; 31(2):71–88.
- Geeseman J, Patrey J, Davy C, Perditto K, Zernickow C. The impact of conflicting spatial representations in airborne unmanned aerial system sensor control. Patuxent River, MD: NAVAIR Patuxent River; 2016. Available from: https://apps.dtic.mil/sti/citations/AD1009801.
- Jin H, Hou LJ, Wang ZG. Military brain science–how to influence future wars. Chin J Traumatol. 2018; 21(5):277–280.
- Kassab A, Le Lan J, Vannasing P, Sawan M. Functional near-infrared spectroscopy caps for brain activity monitoring: a review. Appl Opt. 2015; 54(3):576–586.
- Sulzer J, Haller S, Scharnowski F, Weiskopf N, Birbaumer N, et al. Realtime fMRI neurofeedback: progress and challenges. Neuroimage. 2013; 76:386–399.

## STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION (Required by 39 U.S.C. 3685)

1. Title of Publication: Aerospace Medicine and Human Performance. 2. Publication No. 008-760. 3. Date of Filing: October 1, 2020. 4. Frequency of Issue: Monthly. 5 No. of Issues Published Annually: 12. 6. Annual Subscription Price: \$270. 7 Complete Mailing Address of Known Office of Publication: Aerospace Medical Association, 320 S. Henry St., Alexandria, VA 22314-3579. 8. Complete Mailing Address of Headquarters or General Business Office: Aerospace Medical Association, 320 S. Henry St., Alexandria, VA 22314-3579. 9. Full Names and Complete Mailing Address of Publisher, Editor, and Managing Editor: Publisher --Aerospace Medical Association, 320 S. Henry St., Alexandria, VA 22314-3579. Editor - Frederick Bonato, Ph.D., 2641 John F. Kennedy Blvd., Jersey City, New Jersey 07306-5943. Managing Editor -- Pamela C. Day, B.A., Aerospace Medical Association, 320 S. Henry St., Alexandria, VA 22314-3579. 10. Owner: Aerospace Medical Association, 320 S. Henry St., Alexandria, VA 22314-3579. 11. Known Bondholders, Mortgages, and other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, and Other Securities: None. 12. For Completion by Nonprofit Organizations Authorized to Mail at Special Rates: The purpose, function, and nonprofit status of this organization and the exempt status for Federal income tax purposes has not changed during the preceding 12 months. 13. Publication Name: Aerospace Medicine and Human Performance. 14. Issue Date for Circulation Data: September 2020.

15. Extent and Nature of Circulation:	Ave. No. of Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest Filing Date
a. Total no. copies	2002	1802
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