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Emerging Consciousness at a Clinical Crossroads

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Growing awareness of shortcomings of standard behavioral approaches to the diagnosis and prognosis of patients with disorders of consciousness (DoC) has paved the way for neurotechnological discoveries permitting assessment of consciousness and prediction of its recovery in the absence of overt bedside behaviors. This remarkable scientific leap, once considered impossible by many clinical neuroscientists and philosophers wedded to the orthodoxy that "we can only infer the self-awareness of others by their appearance and their acts" (Plum and Posner 1982) or through first-personal introspective access (Wittgenstein 1953; Kant 1781; Nagel 1974), has not only widened the boundaries of DoC nosology but has revealed new avenues for impactful neurorehabilitative intervention (Young 2017; Edlow et al. 2020). These neurotechnologies, which include neuroimaging and electrophysiologic techniques to detect covert consciousness (i.e., awareness undetectable by standard behavioral examination), are now endorsed by American professional society guidelines, as emphasized by Peterson et al., and by European and other international society guidelines (Kondziella et al. 2020; Comanducci et al. 2020; Giacino et al. 2018). Weaving together recent evidence of clinical utility with epistemological and normative arguments surrounding the value of consciousness and its assessment, Peterson et al. persuasively contend that the provision of these neurotechnologies and allocation of related resources to patients with DoC are ethically justified. While the considerations advanced by the authors in support of this position are rigorous and compelling, they invite an even more pressing question that is left unaddressed: given the ethical imperative of supporting those with emerging consciousness, how can we ensure that patients who stand to benefit from these neurotechnological innovations actually receive them?

Despite current professional society recommendations and growing clinical consensus supporting their use, staggering gaps exist in clinical access to these modalities in our communities and around the world. Only a few quaternary centers worldwide are equipped to collect and analyze advanced neuroimaging and electrophysiologic data to detect consciousness, aid in neuroprognostication and illuminate windows of opportunity for neurorecovery. These gaps in access are particularly conspicuous in light of the recent European Academy of Neurology (EAN) guideline endorsing a composite reference standard in assessing consciousness that supplements standardized clinical behavioral scales (such as the Coma Recovery Scale–Revised (CRS-R) or Full

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Outline of Unresponsiveness (FOUR) score) with advanced functional neuroimaging measures (such as functional magnetic resonance imaging (fMRI) or positron emission tomography (PET)), and electroencephalography (EEG)-based techniques (Kondziella et al. 2020). Evaluating patients with DoC according to the recommended composite reference standard requires that "a given patient should be diagnosed with the highest level of consciousness as revealed by any of the three approaches (clinical [behavioral], EEG, neuroimaging)" (Kondziella et al. 2020). It follows from this that if there is uncertainty about a person's level of consciousness after standardized behavioral examination, and EEG or neuroimaging techniques have not been employed, then the workup remains deficient. Although epidemiologic data on the worldwide incidence and prevalence of DoC are limited, we suspect that many non-communicative persons with DoC are concerningly underdiagnosed or misdiagnosed, as the vast majority of medical centers do not have access to the neurotechnologies or interpretive expertise necessary for a complete DoC workup consistent with this recommended composite standard. A person who is erroneously presumed to be unconscious despite harboring covert awareness may be at heightened risk of becoming agonizingly alienated or isolated if communicative attempts, social interactions, or therapeutic strategies are consequently withheld due to misascriptions of futility. Inaccurate classification of a patient's level of consciousness may lead to other grave consequences, including potential downstream effects on access to neurorehabilitation, analgesia, goals-of-care decision-making, and family coping. It is therefore time to pivot from the question of *whether* allocation of such resources is ethically justified to the more exigent question of *how* to rapidly and responsibly deliver these neurotechnologies to those who need it most.

Our approach to responsibly translating neurotechnologies for the detection and promotion of consciousness in clinical practice is guided by four central neuroethical principles: (1) promoting equity in neurotechnology access; (2) embedding neuroethics research within neurotechnology development and translational processes to understand the experiences and perspectives of patients, surrogates, clinicians and researchers with the aim of integrating normative insights into emerging clinical paradigms; (3) communicating uncertainty about data yielded by novel neurotechnologies with clinical teams, patients and surrogates, while acknowledging the meaningful diagnostic and neuroprognostic information that they could uncover; (4) sensitizing DoC nosology and diagnostic criteria to reflect breakthroughs in neuroscience and neurotechnology (Young and Edlow 2021). Among these, promoting equity in access to neurotechnologies for persons with DoC is perhaps the most formidable and yet vital challenge, largely due to how resource-intensive and expertise-dependent these technologies are. For example, successful clinical implementation of fMRI to detect covert consciousness requires not only access to a modern MRI scanner, but also access to appropriate acquisition protocols, specialized code, analysis pipelines, and a specialist trained to interpret outputs and reliably explain results to primary medical team members and/or surrogates. Impediments to access are especially challenging in low resource settings where neurology expertise and diagnostic tools are scarce and irregularly distributed despite high neurological disease burden (Otubogun 2020). While EEG technologies are generally more affordable in comparison to fMRI, most centers – even those already equipped with EEG systems and neurophysiologists trained in standard EEG interpretation – may face challenges in accessing and clinically implementing appropriate pipelines for non-standard

EEG data acquisition and processing tailored to detect covert consciousness (e.g., power spectral density classification).

Democratizing access to optimal DoC care requires a multilevel approach to facilitate equitable dissemination and adoption of neurotechnologies. At the researcher and developer level, commitment to making code, software and analysis pipelines open-access, interoperable and scalable is vital to ensure that technologies do not remain siloed at their source. Concomitantly, sustained investigations of potentially more accessible and cost-effective strategies to aid in DoC evaluation are imperative, such as the olfactory-sniff test recently described by Arzi and colleagues (Arzi et al. 2020); such efforts should ideally include the development of concordance measures between available diagnostic modalities to inform a rational approach to stepwise implementation. At the hospital and healthcare systems levels, opportunities exist to develop and deploy telemedicine platforms that provide access to specialized DoC expertise in underserved areas domestically and internationally. Conceivably, raw clinical, EEG or neuroimaging data could be collected on site, processed/analyzed remotely by clinicians trained in advanced DoC evaluation, and interpreted results communicated back (synchronously or asynchronously) to the primary medical or rehabilitation teams. Equitable access may be additionally fortified by creating a hub-and-spoke model system for patients with DoC in which networks of secondary medical centers with more limited neurotechnology resources (spokes) are established with connections to central medical centers (hubs) equipped with the comprehensive neurotechnology armamentarium for diagnosing and treating patients with emerging consciousness. Suitable patients may be identified and efficiently routed from a spoke center to a hub center when a higher level of care is needed. Systems of this kind have been widely implemented around other disorders, including stroke, cancer and myocardial infarction, and have demonstrated benefits to patients, insurers and society, along with reductions in costs of care (Elrod and Fortenberry 2017). On the policy level, alignment of financial incentives and clarification of reimbursement policies may further motivate adoption and dissemination of neurotechnologies, especially in resource-constrained settings (Cappellaro, Ghislandi, and Anessi-Pessina 2011). At the institutional and professional society levels, these efforts should be coupled with educational resource building to disseminate knowledge of the utility of neurotechnologies in caring for patients with DoC, and to aid in training of clinicians who practice outside of neurotechnology hubs.

While obstacles surely exist, these guiding principles may serve as a roadmap to proactively steer the development of neurotechnologically advanced, accessible, ethically informed systems of care for patients with emerging consciousness at this historic crossroads in clinical practice.

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References

Arzi Anat, Rozenkrantz Liron, Gorodisky Lior, Rozenkrantz Danit, Holtzman Yael, Ravia Aharon, Bekinschtein Tristan A, Galperin Tatyana, Krimchansky Ben-Zion, and Cohen Gal. 2020. "Olfactory sniffing signals consciousness in unresponsive patients with brain injuries." Nature 581 (7809): 428–433. [PubMed: 32461641]

Cappellaro Giulia, Ghislandi Simone, and Eugenio Anessi-Pessina. 2011. "Diffusion of medical technology: the role of financing." Health policy 100 (1): 51–59. [PubMed: 21055840]

Comanducci A, Boly M, Claassen J, De Lucia M, Gibson RM, Juan E, Laureys S, Naccache L, Owen AM, and Rosanova M. 2020. "Basic and advanced neurophysiology in the prognostic and diagnostic evaluation of disorders of consciousness: review of an IFCN-endorsed expert group." Clinical Neurophysiology.

Edlow Brian L, Jan Claassen, Schiff Nicholas D, and Greer David M. 2020. "Recovery from disorders of consciousness: mechanisms, prognosis and emerging therapies." Nature Reviews Neurology: 1–22. [PubMed: 31827266]

Elrod James K, and Fortenberry John L. 2017. "The hub-and-spoke organization design: an avenue for serving patients well." BMC health services research 17 (1): 25–33. [PubMed: 28077155]

Giacino JT, DI Katz ND Schiff J Whyte, Ashman EJ, Ashwal S, Barbano R, Hammond FM, Laureys S, and Ling GSF. 2018. "Practice guideline update recommendations summary: Disorders of consciousness: Report of the Guideline Development, Dissemination, and Implementation Subcommittee of the American Academy of Neurology; the American Congress of Rehabilitation Medicine; and the National Institute on Disability, Independent Living, and Rehabilitation Research." Neurology 91 (10): 450–460. [PubMed: 30089618]

Kant Immanuel. 1781. "Critique of Pure Reason, trans. JMD Meiklejohn." New York: JM Dent & Sons.

Kondziella Daniel, Bender Andreas, Diserens Karin, van Erp Willemijn, Estraneo Anna, Formisano Rita, Laureys Steven, Naccache Lionel, Ozturk S, and Rohaut Benjamin. 2020. "European Academy of Neurology guideline on the diagnosis of coma and other disorders of consciousness." European journal of neurology 27 (5): 741–756. [PubMed: 32090418]

Nagel Thomas. 1974. "What is it like to be a bat?" The philosophical review 83 (4): 435–450.

Otubogun Folajimi M. 2020. "Neurological Morbidity and Mortality in a Neurological Low-Resource Setting: A 2-Year Audit of a Nigerian Hospital." The Neurologist 25 (4): 93–96. [PubMed: 32618837]

Plum Fred, and Posner Jerome B. 1982. The diagnosis of stupor and coma. Vol. 19. Oxford University Press, USA.

Wittgenstein Ludwig. 1953. "Philosophical investigations. Philosophische Untersuchungen."

Young Michael J. 2017. ""Consciousness" as a vague predicate." AJOB Neuroscience 8 (3): 157–159.

Young Michael J. and Edlow Brian L.. 2021. "The Quest for Covert Consciousness: Bringing Neuroethics to the Bedside." Neurology. In press.