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Neurocriminalistics in the Era of the Brain–Computer Interface: Balancing Investigative Effectiveness and Human Rights Protection in Light of the UNESCO Samarkand Recommendation

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https://doi.org/10.21684/2412-2343-2026-13-2-37-63

Received: December 11, 2025
Reviewed: January 3, 2026
Accepted: March 6, 2026

Abstract. Fifth-generation brain–computer interface neurotechnologies enable the instrumental registration of cognitive traces of crime, transforming the conditions of investigative practices. Brain fingerprinting, employing event-related brain potentials, allows the establishment of the presence or absence of specific information in memory without verbal mediation. The adoption of the first global neuroethical standard—the UNESCO Recommendation on the Ethics of Neurotechnology adopted on November 11, 2025 in Samarkand at the 43rd session of the UNESCO General Conference—creates an international legal framework that has not yet been conceptualized in forensic and criminal procedural terms in post-Soviet and BRICS legal systems. The aim of this article is to substantiate "neurocriminalistics" as a new branch of forensic science and to develop a model of legal regulation of "neuroexpertise" in the criminal procedural law of the Republic of Uzbekistan. The research methodology combines comparative legal analysis of the regulatory frameworks of Uzbekistan, BRICS countries (Brazil, Russia, India, China, South Africa), Chile, the European Union and the United States; inductive generalisation of criminal neurotesting cases; functional analysis of investigative actions under the Criminal Procedure Code of Uzbekistan; and normative modelling of admissibility. The research contribution lies in five proposals: an instrumentally registrable ideational trace as an autonomous object of forensic research; the attributive gap between neurorecognised familiarity and evidentially relevant knowledge; the two-tier admissibility regime distinguishing orienting application in operational-investigative activity from procedural application in particularly grave cases; the "Samarkand Process" as an institutional mechanism for regional implementation; and "neuroexpertise" as an autonomous form of forensic examination.

Keywords: brain–computer interface; neurocriminalistics; brain fingerprinting; mental privacy; cognitive liberty; the UNESCO Recommendation; Ethics of Neurotechnology; Samarkand; criminal investigation; neuroexpertise; BRICS; law.

To cite: Gulyamov, S. S., et al. (2026). Neurocriminalistics in the era of the brain–computer interface: Balancing investigative effectiveness and human rights protection in light of the UNESCO Samarkand Recommendation. *BRICS Law Journal*, *13*(2), 37–63.

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Introduction

Forensic science has historically operated within a resilient dichotomy: material traces have been registered instrumentally, whereas ideational traces have been accessible only through verbal testimony.[1] Brain fingerprinting, first described by Farwell and Donchin in 1991,[2] rests on a positive event-related potential that is maximal at the midline parietal scalp peaking 300 to 800 milliseconds after stimulus onset.[3]

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1 Ienca, M., & Andorno, R. (2017). Towards new human rights in the age of neuroscience and neurotechnology. *Life Sciences, Society and Policy, 13*, Article 5.

2 Farwell, L. A., & Donchin, E. (1991). The truth will out: Interrogative polygraphy ("lie detection") with event-related brain potentials. *Psychophysiology, 28*(5), 531–547.

3 Farwell, L. A., Richardson, D. C., & Richardson, G. M. (2013). Brain fingerprinting field studies comparing P300-MERMER and P300 brainwave responses in the detection of concealed information. *Cognitive Neurodynamics, 7*(4), 263–299.

The subject's memory becomes exposed to instrumental analysis without verbal mediation by the subject. The institutional environment changed in autumn 2025. The 43rd General Conference of UNESCO was held in Samarkand from October 30 to November 13, 2025,[4] which led to the adoption of the Recommendation concerning the Ethics of Neurotechnology on November 11, 2025;[5] it entered into force on November 12,[6] marking the emergence of the first global regulatory framework on the ethics of neurotechnology.[7] The panel of experts headed by Hervé Chneiweiss and Nita Farahany relied on over 8,000 submissions received over six years.[8] The adoption on Uzbek territory—henceforth the "Samarkand Recommendation"—establishes a unique geopolitical position for the country.

The doctrinal foundations of this regulatory wave were laid earlier. Ienca and Andorno articulated four neurorights in 2017—cognitive liberty, mental privacy, mental integrity, and psychological continuity;[9] Yuste and the Morningside Group concurrently advanced four ethical priorities in *Nature*—privacy and consent, agency and identity, augmentation, and bias.[10] Chile became the first country to constitutionalise mental privacy through Law No. 21,383 amending Article 19 of its Constitution in 2021;[11] the Chilean Supreme Court operationalised this protection in a 2023 ruling against Emotiv, ordering the deletion of a user's neural data.[12]

The BRICS jurisdictions have already articulated their response. Brazil's Rio Grande do Sul incorporated neurorights into its Constitution on December 20, 2023,[13] while

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4 UNESCO. (2025a). *Recommendation on the Ethics of Neurotechnology*. Adopted by the General Conference at its 43rd session, Samarkand, November 11, 2025. https://www.unesco.org/en/legal-affairs/recommendation-ethics-neurotechnology

5 UNESCO, 2025a [adopted text].

6 UNESCO UK. (2025). *UNESCO adopts first global framework on neurotechnology ethics*. UNESCO UK News. https://unesco.org.uk/news/unesco-adopts-first-global-framework-on-neurotechnology-ethics

7 Maynard, P. (2026). *UNESCO adopts first global framework on neurotechnology ethics*. Global Policy Watch. https://www.globalpolicywatch.com/2026/01/unesco-adopts-first-global-framework-on-neurotechnology-ethics/

8 UNESCO. (2025, November 12). *Ethics of neurotechnology: UNESCO adopts first global standard for cutting-edge technology*. UNESCO News. https://www.unesco.org/en/articles/ethics-neurotechnology-unesco-adopts-first-global-standard-cutting-edge-technology

9 Ienca & Andorno, 2017.

10 Ienca, M. (2021). On neurorights. *Frontiers in Human Neuroscience, 15*, Article 701258.

11 Carey, G. (2021). *Law No. 21,383: Constitutional reform to establish that the scientific and technological development will be at the service of the people is published*. Carey Newsroom. https://www.carey.cl/en/law-no-21383-constitutional-reform-to-establish-the-scientific-and-technological-development-at-the-service-of-the-people-is-published/

12 Stanford Law School. (2026, April 27). Even Chile's neurorights leave inferred mental data in a gray zone. *Stanford Law and Biosciences Blog*.

13 Neurorights Foundation. (n.d.). Brazil. Neurorights Foundation Country Pages. https://neurorights-foundation.org/brazil

federal PEC 29 advances mental integrity and algorithmic transparency at the national level.[14] China issued the Guidelines for Research Ethics in Brain–Computer Interface in February 2024.[15] India's Supreme Court in *Selvi v. State of Karnataka* held that compulsory neuroscientific testing violates Article 20(3) of the Constitution.[16] Russia acknowledged the Recommendation through its Permanent Delegation to UNESCO;[17] South African scholarship addresses the admissibility of electronic evidence in *S v. Harper* and *S v. Brown*.[18] Against this architecture, post-Soviet jurisdictions—especially Uzbekistan—have not developed a coherent forensic-procedural response.

Documented criminal cases demonstrate the dual capacity of the technology. In *Grinder* (Macon County, Missouri, August 1999), a brain fingerprinting test produced a guilty plea six days later in exchange for life imprisonment without parole.[19] In *Harrington*, the Iowa Supreme Court reversed a murder conviction on February 26, 2003; the State declined a retrial, and the appellant was released after twenty-three years.[20] Conversely, on June 12, 2008, Aditi Sharma became the first person convicted of murder on the basis of a brain scan, an outcome later overturned on appeal.[21] In 2011, the Court of Como reduced Stefania Albertani's sentence from life imprisonment to twenty years on the basis of structural brain abnormalities and the MAOA-L genotype.[22] The spectrum – exoneration, premature conviction, sentence mitigation, and constitutional veto – defines what a national normative model must address in advance.

The article is structured around five interlocking proposals that articulate the study's original contribution. *First*, the authors introduce the *instrumentally registrable ideational trace* (IRIT) as a third category of forensic trace, irreducible to the material trace or the classical ideational trace. *Second*, the authors advance the concept of the attributive

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14 Agência Brasil. (2024). *Experts urge safeguarding mental privacy amid strides in neurotech*. https://agenciabrasil.ebc.com.br/en/geral/noticia/2024-03/experts-urge-safeguarding-mental-privacy-amid-strides-neurotech

15 Poo, M. M. (2024). China's new ethical guidelines for the use of brain-computer interfaces. *National Science Review, 11*(4), nwae154.

16 Lawbhoomi. (n.d.). *Selvi v. State of Karnataka*: Case analysis. Lawbhoomi Case Briefs.

17 Permanent Delegation of the Russian Federation to UNESCO. (2025, November 18). *UNESCO Member States approve the Recommendation on the Ethics of Neurotechnology*. UNESCO Russian Federation Commission News.

18 Botes, M., & Naidoo, T. (2025, June 5). *Resting a case in reality: Virtual reality, neurotechnologies, and judicial evidence*. DataLaw Africa. https://www.datalaw.africa/2025/06/05/resting-a-case-in-reality/

19 Farwell Brain Fingerprinting Laboratories. (n.d.). *Farwell Brain Fingerprinting*. https://farwellbrainfingerprinting.com/

20 Farwell Brain Fingerprinting Laboratories, n.d.

21 Murphy, E. R. (2009, April 2). Update on Indian BEOS case: Accused released on bail. *Stanford Law and Biosciences Blog*.

22 Stanford Law School. (2011, September 3). Another brain mitigation criminal sentence from Italy. *Stanford Law and Biosciences Blog*.

gap, identifying the discontinuity between technologically valid recognition and legally probative knowledge of crime. *Third*, the authors set out a *two-tier admissibility regime*: orienting application without procedural status in operational-investigative activity, and procedural application as neuroexpertise restricted to particularly grave offences. *Fourth*, the authors prove that the "*Samarkand Process*" can be considered as an institutional mechanism for regional implementation of the UNESCO Recommendation by structural analogy with the Helsinki and Bologna Processes. *Fifth*, the authors describe *neuroexpertise as an autonomous category* of forensic examination. These propositions are developed across the eight subsequent sections.

1. Technological Landscape of BCI 5.0

The forensic relevance of brain–computer interface technologies depends on their methodological maturity. Brain fingerprinting was first articulated by Farwell and Donchin in *Psychophysiology* in 1991 employing event-related potentials in an interrogative polygraphy paradigm to detect concealed knowledge.[23] The diagnostic substrate is the P300, a positive voltage potential maximal over the midline parietal scalp at electrode site Pz of the International 10–20 System, peaking 300 milliseconds or more after the eliciting stimulus.[24] Farwell subsequently expanded the diagnostic window with the P300-MERMER complex—Memory and Encoding Related Multifaceted Electroencephalographic Response—extending interpretation up to approximately 1,400 milliseconds.

The Indian methodological variant developed in parallel. Brain Electrical Oscillation Signature Profiling (BEOS) was developed by C. R. Mukundan, formerly Head of Clinical Psychology at the National Institute of Mental Health and Neurosciences in Bangalore, while consulting on the TIFAC-DFS project.[25] By 2017, BEOS had been deployed in over 700 police investigations across India. Its operational protocol uses a 32-electrode EEG cap to record electrophysiological responses while crime-relevant stimuli are read aloud, distinguishing "experiential knowledge"—recall of personally experienced events—from "knowledge" derived from external sources.

The technological landscape was qualitatively transformed in 2024 with the first human implantation of an invasive BCI by Neuralink. On January 28, 2024, Noland Arbaugh, a 29-year-old quadriplegic, became the first recipient of the Telepathy N1 implant under the PRIME (Precise Robotically Implanted Brain–Computer Interface) study.[26] By early 2025, three participants had accumulated over 4,900 hours of

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23 Farwell & Donchin, 1991.

24 Farwell, Richardson & Richardson, 2013.

25 Wikipedia contributors. (2025). Brain electrical oscillation signature profiling. *Wikipedia*.

26 Neuralink. (2025). *A year of Telepathy*. https://neuralink.com/updates/a-year-of-telepathy/

operational use, controlling external devices through neural signals.[27] This invasive paradigm dramatically expanded the bandwidth of brain-derived data potentially relevant to forensic investigation.

The economic trend emphasizes the forensic necessity. According to data provided by Grand View Research, the total addressable market for invasive brain–computer interfaces reached a considerable size by 2025 and will continue growing through the early 2030s.[28] Similarly, UNESCO reports that neurotechnology investment increased 700 percent from 2014 to 2021.[29] Market consolidation, with a focus on Neuralink, Synchron, Emotiv, NeuroSky, and Blackrock Neurotech, positions consumer-grade neural devices in the forecast horizon before procedural regulation is developed.

The strategic response of China exemplifies the geopolitical aspect. According to the Chinese government, BCI breakthroughs are expected to take place by 2027 and international competitiveness should be achieved by 2030.[30] The BCI industry in China reached RMB 3.2 billion in 2024, experiencing considerable yearly growth. For forensic purposes, the strategic perspective is clear: state-sponsored industrial efforts create uneven distribution of signal-processing capability in a few jurisdictions, thereby creating asymmetric capabilities of generating evidentiary material.

Limitations associated with technological development also deserve attention. A series of experiments conducted by Rosenfeld et al. showed that the use of simple covert mental countermeasures to produce concealed responses to irrelevant stimuli substantially decreased P300 detection performance: the hit rate decreased from 82 percent to 18 percent in the six-probe protocol and from 92 percent to 50 percent in the one-probe protocol.[31] The message is obvious—any forensic use of the technology will require accounting for considerable false-negative probability if the suspect is sufficiently motivated and minimally trained.

On the other hand, recent improvements to the protocol reduced some of the technology's vulnerability. Developed in 2008 by Rosenfeld et al., the Complex Trial Protocol allows the detection of countermeasure use of countermeasures using reaction time distributions, achieving high subject-detection rates among guilty

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[27] Newton, C. (2025, January 30). *Neuralin's first human trials mark one year of control through telepathy*. The Debrief. https://thedebrief.org/neuralinks-first-human-trials-mark-one-year-of-control-through-telepathy/

[28] Grand View Research. (2025). *Brain–computer interface market size, share & trends analysis report, 2026–2033*. https://www.grandviewresearch.com/press-release/global-brain-computers-interface-market

[29] UNESCO, 2025b.

[30] Towards Healthcare. (2025). *Brain–computer interface market: Insights and forecast. Industry insights report*. https://www.towardshealthcare.com/insights/brain-computer-interface-market

[31] Rosenfeld, J. P., et al. (2004). Simple effective countermeasures to P300-based tests of detection of concealed information. *Psychophysiology, 41*(2), 205–219.

participants in several independent experiments.[32] At the same time, any protocol improvement presupposes laboratory settings, meaning that transition to forensic use faces a major methodological obstacle.

The result is straightforward. Fifth-generation BCI technology has matured methodologically enough to detect cognitive evidential traces, but has not yet developed sufficiently to serve as an autonomous form of evidence capable of proving guilt. A national regulatory model needs to treat neurorecognition as supplementary to other evidence—a technique capable of informing forensic procedures and corroborating other information, but unable to prove guilt on its own. This is the methodological framework for the comparative analysis of cases presented in the following part of the article.

2. Global Case Analysis

The literature in forensic psychology contains a varied collection of criminal cases where there has been an instrumental registration of cognitive traces. These have been classified into three procedural types: those that resulted in convictions or guilty pleas; those that resulted in exoneration or acquittal; and those where the evidence was excluded by the courts due to inadequate methodology.

2.1. United States Practice

The leading case of judicial exclusion is *Slaughter v. State*, decided by the Oklahoma Court of Criminal Appeals in 2005. Jimmy Ray Slaughter was sentenced to death for the 1991 murder of Melody Wuertz and her infant daughter Jessica in Edmond, Oklahoma; his defence team commissioned a brain fingerprinting test from Lawrence Farwell to demonstrate the absence of crime-relevant information in his memory.[33] The Oklahoma Court of Criminal Appeals rejected the application, characterising the brain fingerprinting evidence as "uncorroborated and likely inadmissible" and holding that the procedural deadlines for post-conviction relief had passed.[34] Slaughter was executed by lethal injection, becoming a paradigm case of forensic neuroevidence failing to meet the timeliness threshold of post-conviction procedure.

A parallel exclusion in the federal courts concerns functional magnetic resonance imaging. In *United States v. Semrau*, decided in 2010 in the Western District of

32 Rosenfeld, J. P., et al. (2008). The Complex Trial Protocol (CTP): A new, countermeasure-resistant, accurate, P300-based method for detection of concealed information. *Psychophysiology, 45*(6), 906–919.

33 United Press International. (2004, March 1). *New technology used in death row case*. UPI Defense News.

34 *Slaughter v. State*, 105 P.3d 832 (Okla. Crim. App. 2005). Justia U.S. Supreme Court Center. https://law.justia.com/cases/oklahoma/court-of-appeals-criminal/2005/441668.html

Tennessee and affirmed by the Sixth Circuit in 2012, Magistrate Judge Tu M. Pham excluded fMRI lie-detection evidence offered by Cephos Corporation under Federal Rule of Evidence 702 and *Daubert*.[35] The court found that while fMRI satisfied the testability and peer-review prongs of *Daubert*, real-world error rates were unknown and standardised forensic protocols were absent.[36] *Semrau* established the first appellate precedent against brain-based deception detection.

The doctrinal influence of neuroscience on US capital sentencing is exemplified by *Roper v. Simmons*, decided March 1, 2005, in which the Supreme Court invoked adolescent brain development research to invalidate the death penalty for offenders under 18.[37] The case demonstrates that neuroscience enters constitutional jurisprudence not only as case-specific evidence but also as a systemic doctrinal foundation.

2.2. Middle Eastern Practice: United Arab Emirates

A novel operational deployment emerged in the United Arab Emirates in 2021. The Dubai Police General Department of Forensic Science and Criminology applied a "memory print" application based on P300 brainwave detection to identify the perpetrator of a homicide.[38] According to Major-General Dr Ahmed Eid Al Mansouri, Director of the General Department, the deployment followed a year of operational testing and is intended to support, rather than replace, conventional forensic evidence in criminal investigations.[39] The Emirati deployment exemplifies a corroborative—rather than autonomous—admissibility regime.

2.3. The BRICS Legal Space: Comparative Practice

The experience of BRICS countries warrants dedicated examination. The five jurisdictions—Brazil, Russia, India, China, South Africa—collectively encompass approximately 3.2 billion inhabitants and represent the principal locus of normative innovation in the Global South.

Brazil. The Brazilian regulatory architecture combines doctrinal scholarship with sub-national legislative innovation. The state of Rio Grande do Sul became the first Brazilian jurisdiction to incorporate neurorights into its constitution on

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35 Lowenberg, K. (2010, June 1). fMRI lie detection fails its first hearing on reliability. *Stanford Law and Biosciences Blog*.

36 Woodruff, W. A. (2010, September 17). Functional magnetic resonance imaging to detect deception: Not ready for the courtroom. *SSRN*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1809761

37 *Roper v. Simmons*, 543 U.S. 551 (2005). Justia U.S. Supreme Court Center. https://supreme.justia.com/cases/federal/us/543/551/

38 Khaleej Times Staff. (2021, October 19). *Dubai Police nab murderer by looking into his brain*. Khaleej Times. https://www.khaleejtimes.com/uae/dubai-police-nab-murderer-by-looking-into-his-brain

39 Al Shouk, A. (2021, January 25). *Dubai Police map brainwaves to solve murder mystery: 'P300 wave' helps police identify killer among other workers in warehouse murder case*. Gulf News. https://gulfnews.com/uae/government/dubai-police-map-brainwaves-to-solve-murder-mystery-1.76725468

December 20, 2023, working in collaboration with Vice-Governor Gabriel Souza and Procuradora Camila Pintarelli.[40] At the federal level, Constitutional Amendment Bill PEC 29, filed in June 2023, was inspired by the Chilean precedent and the Neurorights Foundation framework, and is awaiting consideration by both chambers of the National Congress.[41]

Russia. Russian forensic doctrine has established a sophisticated framework for psychophysiological expertise. The Russian Ministry of Justice promulgated the first legal regulation of polygraph use by the Federal Security Service in 1993, with subsequent extension to the Ministry of Internal Affairs in 1994 and to the Ministry of Defence in 1998.[42] The Code of Criminal Procedure of the Russian Federation does not specifically address polygraph evidence, generating interpretive doctrine that admits psychophysiological assessments as expert testimony where qualified methodology is observed.[43] The Russian framework provides a regulatory analogue for post-Soviet jurisdictions including Uzbekistan.

India. The Indian experience encompasses both extensive operational deployment and constitutional restriction. Brain Electrical Oscillation Signature Profiling has been used in over 700 police investigations in India, primarily as an investigative-orienting tool combined with polygraph and narcoanalysis.[44] The constitutional limit was set in *Selvi v. State of Karnataka*, decided May 5, 2010, holding that involuntary administration violates Article 20(3) and Article 21 of the Constitution.[45] The Court permitted voluntary testing under safeguards but excluded test results themselves from evidentiary status.

China. The Chinese regulatory architecture combines ethics governance with state-led industrial policy. The Ministry of Science and Technology issued the Guidelines for Research Ethics in Brain–Computer Interface in February 2024,

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40 Neurorights Foundation. (n.d.). *Latin America: Advocacy*. Neurorights Foundation Advocacy Pages. https://www.neurorightsfoundation.org/advocacy/latin-america

41 Agência Brasil. (2024). *Bill outlines protection of mental privacy in age of neurotech*. https://agenciabrasil.ebc.com.br/en/geral/noticia/2024-03/bill-outlines-protection-mental-privacy-age-neurotech

42 Office of Justice Programs. (n.d.). *Criminalistics: The use of polygraph in Russia: Modern level and development*. NCJRS Virtual Library Abstract. https://www.ojp.gov/ncjrs/virtual-library/abstracts/criminalistics-use-polygraph-russia-modern-level-and-development

43 LieDetectorTest.com. (n.d.). *Polygraph history: Russia, KGB labs and modern courts*. LieDetectorTest.com Knowledge Base. https://liedetectortest.com/polygraph/polygraph-history-russia-kgb-labs-modern-courts

44 Aggarwal, N. K. (2017). Lie detection by brain electrical oscillation signature profiling: An emerging neuroforensic technique. *New Zealand Criminal Law Review, 2017*, 416–438. https://www.nzlii.org/nz/journals/NZCrimLawRw/2017/22.html

45 *Selvi & Ors. v. State of Karnataka & Anr.*, AIR 2010 SC 1974. Supreme Court of India. https://indiankanoon.org/doc/338008/

modelled on the Declaration of Helsinki framework.[46] In March 2025, the Chinese National Healthcare Security Administration added new categories to its neurocare guidelines, including implantation and removal fees for invasive BCIs.[47]

South Africa. South African law has not yet developed specific neuroforensic regulation. The principal entry point for neurotechnological evidence is the existing electronic-evidence framework. In *S v. Harper*, the court held that computer-generated printouts may qualify as documents under the Criminal Procedure Act; in *S v. Brown*, the court warned against automatically categorising electronic evidence as hearsay requiring case-by-case assessment of authenticity, relevance and consistency with documentary-evidence rules.[48] South African neurolaw scholarship is developing within the broader medico-legal framework of pathological criminal incapacity.

2.4. Comparative Findings

The comparative analysis yields three doctrinal observations. *First*, no jurisdiction has accepted brain-based recognition evidence as an autonomous proof of guilt; admissibility is uniformly conditioned on corroboration. *Second*, exclusion grounds vary across legal traditions: common-law jurisdictions (US, India) emphasise *Daubert*-type reliability and constitutional self-incrimination protections, while civil-law jurisdictions invoke evidentiary standards and procedural-deadline rules. *Third*, BRICS jurisdictions lack an integrated regulatory model; each jurisdiction has developed its framework in isolation. The institutional gap that the Samarkand Process is designed to address—coordinated implementation of the UNESCO Recommendation across the post-Soviet space and the BRICS community—is therefore not abstract but corresponds to a documented absence of comparative coordination.

3. Constitutional and International Legal Framework

The constitutional and international legal framework governing neurotechnology in 2026 forms a four-layered architecture: the universal layer of UN treaty law adopted before the neurotechnological turn; the new soft law layer represented by the Samarkand Recommendation; the constitutional-domestic layer of states that have undertaken explicit reform; and the doctrinal layer of regional constitutional traditions where reform is yet pending. The dynamics among these layers determine the regulatory space within which Uzbek neurocriminalistics must be situated.

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[46] Liu, C. (2024, February 19). *China rolls out ethical guideline for brain-computer interfaces research*. Global Times. https://www.globaltimes.cn/page/202402/1306687.shtml

[47] Gielas, A. M. (2025, August 21). Warfare at the speed of thought: Can brain–computer interfaces comply with IHL? *Humanitarian Law & Policy Blog (ICRC)*. https://blogs.icrc.org/law-and-policy/2025/08/21/warfare-at-the-speed-of-thought-can-brain-computer-interfaces-comply-with-ihl/

[48] Botes & Naidoo, 2025.

The universal layer rests on Article 17 of the International Covenant on Civil and Political Rights, which prohibits arbitrary or unlawful interference with privacy. Its authoritative interpretation, General Comment No. 16 of the Human Rights Committee, was adopted in 1988, three decades before the operational maturation of brain–computer interfaces. It does not contain any specific reference to mental privacy or neural data.[49] Contemporary scholarship has identified a normative gap: the unique sensitivity of neural data—capable of revealing cognitive and emotional states without verbal mediation—calls for an interpretive expansion of the existing covenant framework, whether through revised general comments or through evolutive jurisprudence.[50] The same scholars argue that the Human Rights Committee should develop a successor general comment capable of addressing workplace neurotechnology and "*bossware*" environments where consent is structurally compromised by power asymmetry.

Adjacent treaty instruments offer partial complements. Article 17 of the Convention on the Rights of Persons with Disabilities articulates a right to physical and mental integrity, providing the closest treaty antecedent to the contemporary concept of mental integrity in the neurorights tradition. Article 5(1) of the American Convention on Human Rights similarly recognises physical, mental and moral integrity. However, neither instrument addresses the specific threat profile generated by direct instrumental access to brain activity, and the European Court of Human Rights has not yet developed jurisprudence on neurotechnological intrusion under Article 8 of the European Convention. The Samarkand Recommendation thus enters a regulatory space where preexisting instruments are general, fragmented, and silent on the specific question of cognitive surveillance.

The Samarkand Recommendation addresses this gap through specific provisions of forensic relevance. Mental privacy is identified as the foundational concern—protecting "the most intimate part of the self" because it is fundamental to personal identity and agency.[51] The instrument frames neurotechnology within a human rights architecture emphasising dignity, freedom of thought, mental privacy and autonomy, calling on states to adopt legal measures preventing applications that facilitate coercive control, unlawful surveillance, or manipulation.[52] These provisions

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[49] UN Human Rights Committee. (1988). *General Comment No. 16: Article 17 (Right to Privacy)*. University of Minnesota Human Rights Library.

[50] Sosa Navarro, M. (2026). Workplace neurosurveillance: Is the employee's mental privacy protected under international law? *BioLaw Journal – Rivista di BioDiritto*, Special Issue 1/2026, 93–114. https://teseo.unitn.it/biolaw/article/download/3985/4263

[51] The Policy Edge. (2025, November 6). *UNESCO adopts first global ethical standard for neurotechnology*. The Policy Edge – Reports/Data Releases. https://www.policyedge.in/p/unesco-adopts-first-global-ethical

[52] Lee, B. H. (2026, March 30). Who owns digital thoughts? The limits of property law and the 2025 UNESCO Recommendation on the Ethics of Neurotechnology. *Stanford Law and Biosciences Blog*.

translate directly into criminal-procedure constraints: any forensic deployment of neurotechnology must be specifically authorised, narrowly tailored, and subject to robust judicial oversight.

Three concrete protections defined by the Recommendation establish boundaries directly relevant to investigative practice. First, freedom of thought is articulated as a right to choose whether or not to be subjected to neurotechnology at any time, with consent that is freely given and informed.[53] Second, the instrument establishes that workplace and educational deployment must be strictly voluntary and opt-in, with explicit prohibition on use for performance evaluation or punitive measures.[54] Third, governance frameworks for non-therapeutic enhancement must be created, distinguishing acceptable applications from those that undermine dignity, identity, or equal opportunity.[55]

The constitutional-domestic layer demonstrates two distinct implementation models. The Latin American model, exemplified by Chile's 2021 reform of Article 19 of its Constitution, anchors mental integrity at the highest legal level and authorises subsequent statutory regulation of brain activity and derived data. The Brazilian model, developed at the sub-national level in Rio Grande do Sul on 20 December 2023 and at the federal level through PEC 29, illustrates a federalist trajectory in which neurorights advance asynchronously through state and national instruments. These two models supply Uzbekistan with two architectures of constitutional incorporation—direct amendment versus interpretive integration—between which a deliberate choice must be made.

The Constitution of the Republic of Uzbekistan, in its 2023 version adopted through referendum on April 30, 2023, contains a developed catalogue of rights structurally amenable to neuroprotective interpretation. Article 27 guarantees the right to freedom and personal inviolability;[56] Article 31 establishes the inviolability of private life, personal and family secrets, the protection of honour and dignity, and includes an express right to the protection of personal data and to the deletion of unlawfully collected data.[57] The norm prohibiting medical and scientific experiments without consent provides an existing constitutional anchor for the consent requirement that the Samarkand Recommendation extends to neuroexpertise.[58] Article 19 establishes that human rights and freedoms belong to every person from birth and are recognised

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53 Maynard, 2026.

54 The Policy Edge, 2025.

55 Maynard, 2026.

56 Republic of Uzbekistan. (2023). Constitution of the Republic of Uzbekistan (as amended through the April 30, 2023 referendum). Official portal. https://constitution.uz/en/clause/index

57 Republic of Uzbekistan, Constitution, 2023.

58 Embassy of the Republic of Uzbekistan in Ukraine. (n.d.). Constitution of the Republic of Uzbekistan. https://uzbekistan.org.ua/en/uzbekistan-en/constitution.html

in accordance with universally recognised norms of international law, providing the doctrinal bridge through which the Samarkand Recommendation can be domestically incorporated.[59]

BRICS jurisdictions and the post-Soviet space exhibit institutional fragmentation. No coordinated mechanism currently exists for joint implementation of the Samarkand Recommendation across these jurisdictions, despite their shared exposure to identical risks: invasive consumer neurotechnology, employer monitoring, and forensic deployment without procedural safeguards. The Samarkand Process—by structural analogy with the Helsinki Process on European security and the Bologna Process on higher education—is intended to fill precisely this institutional gap, beginning with a regional declaration aligned to the Samarkand Recommendation, followed by the harmonisation of statutory neurodata-protection regimes and the establishment of a regional registry of certified neuro-forensic experts. Having mapped the doctrinal foundation, the article now turns to the comparative human rights analysis on which the design of such an institutional mechanism depends.

4. Positive and Negative Dimensions of Forensic Neurotechnology Through the Lens of Human Rights

The forensic deployment of neurotechnology produces a duality of consequences that must be evaluated against the full architecture of human rights. The same instrumental capacity that may exonerate the wrongly convicted may also expose suspects to unprecedented intrusion into the cognitive sphere. Section 4 maps this duality across three positive dimensions, four negative dimensions, and four cross-cutting tensions that any national regulatory model must resolve.

The first positive dimension is the protection of the right to a fair trial through the reduction of judicial error. Brain fingerprinting and event-related potential methods can corroborate alibis, exclude wrongful suspects, and identify cases of mistaken identification. The right to an effective remedy under Article 2(3) of the ICCPR, and the constitutional presumption of innocence in Uzbekistan and across the BRICS jurisdictions, are therefore advanced—not undermined—when neurotechnology is deployed exclusively in an exonerative capacity within the safeguards of voluntary consent.

The second positive dimension is the strengthening of the prohibition against torture and degrading treatment. Conventional interrogation techniques in many jurisdictions retain practices that approach the boundary of Article 7 of the International Covenant on Civil and Political Rights (ICCPR). Voluntary, non-invasive registration of event-related brain potentials is, by its physical nature, less coercive

[59] UNHCR Rights Mapping and Analysis Platform. (2025). Constitution of the Republic of Uzbekistan. UNHCR RIMAP – Uzbekistan country page. https://rimap.unhcr.org/node/62747

than prolonged custodial questioning. Properly regulated, neuroexpertise can replace physically coercive interrogation with an instrumental procedure that respects bodily integrity—provided that the consent dimension is genuinely free and not the product of custodial coercion.

The third positive dimension concerns vulnerable persons. Subjects with communication impairments, post-traumatic conditions, or cognitive limitations may be unable to participate effectively in verbal interrogation; for these persons, neuro-instrumental methods can in principle restore evidentiary access without exposing the subject to the cognitive overload of conventional questioning. Article 13 of the Convention on the Rights of Persons with Disabilities, requiring effective access to justice, supports a supervised and consent-based deployment in this narrow class of cases.

The first negative dimension is the threat to mental privacy. Even non-invasive electroencephalographic registration produces neural data that may reveal cognitive and affective states extending well beyond the specific question of crime-relevant recognition.[60] The risk of "function creep"—the expansion of forensic neurodata collection into general biometric surveillance—is therefore not theoretical but structural and must be addressed through purpose-limitation and data-deletion rules.

The second negative dimension concerns the privilege against self-incrimination. The compulsory use of neurotechnology in criminal investigation may violate not only privacy and freedom of thought, but also fair-trial guarantees including the protection against self-incrimination.[61] The classification of neural data—as physical evidence subject to subpoena, or as testimonial communication protected by *nemo tenetur*—determines the entire architecture of admissibility. The Indian Supreme Court resolved this in *Selvi* by classifying involuntary neuroscientific testing as testimonial compulsion; the question is open in most other BRICS jurisdictions.

The third negative dimension is the risk of inhuman and degrading treatment when adverse legal consequences are derived from inferred mental states rather than from acts. Decisions about an individual's liberty based on unexpressed thoughts or behavioural dispositions, as opposed to overt action, may constitute a fair-trial violation or inhuman and degrading treatment.[62] The implication for forensic doctrine is that recidivism prediction based on neural activity, however statistically reliable, lies outside the legitimate scope of investigative neurotechnology.

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[60] Rhodes, C. (2025, November 11). Neurorights and mental privacy. *UAB Institute for Human Rights Blog*. https://sites.uab.edu/humanrights/2025/11/11/neurorights-and-mental-privacy/

[61] Harper, E., & Istace, T. (2025, November 11). *Neurotechnology and human rights: An audit of risks, regulatory challenges, and opportunities*. Research Brief. Geneva Academy of International Humanitarian Law and Human Rights.

[62] Harper & Istace, 2024.

The fourth negative dimension is cognitive liberty. Cognitive liberty has been characterised as comprising both the right to use neurotechnologies and protection against their coercive and non-consensual use.[63] In the criminal-procedural context, cognitive liberty operates as a constitutional limit on investigative authority: the state may not compel the disclosure of cognitive content even where the technical means are available.

Four cross-cutting tensions structure the regulatory choice. *First*, there is a tension between investigative effectiveness in particularly grave offences and the universal applicability of mental-privacy protection—a tension that the proposed two-tier admissibility regime is designed to resolve through restrictive procedural admissibility. *Second*, there is a tension between the right to scientific progress, articulated in Article 15 of the International Covenant on Economic, Social and Cultural Rights (ICESCR), and the precautionary principle that governs novel technologies of unknown long-term effects. *Third*, there is a tension between national sovereignty in criminal procedure and the transnational character of neurodata flows, which calls for the regional coordination that the Samarkand Process is designed to provide. *Fourth*, there is a tension between consent as a procedural safeguard and the structural impossibility of free consent in custodial environments—a tension that becomes particularly acute when the suspect is offered neuroexpertise as an alternative to prolonged interrogation.

The synthesis of positive and negative dimensions yields a balanced normative position. Neurotechnology in a criminal investigation is neither categorically prohibited nor freely admissible; its legitimate operational space is defined by the intersection of four conditions: voluntary and uncoerced consent; restriction to particularly grave categories of offence; corroborative—rather than autonomous—evidentiary status; and judicial supervision at the authorization stage. These four conditions form the structural foundation of the forensic and procedural model developed in the next section, in which the doctrinal categories of the instrumentally registrable ideational trace and the attributive gap formalise the technical and legal limits within which the four conditions operate.

5. Forensic-Criminalistic and Procedural Analysis

5.1. Doctrinal Status of the Cognitive Trace

Classical criminalistics, structured around the Locardian exchange principle, distinguishes two categories of forensic trace: the material trace, formed by the physical interaction between the offender and the crime environment, and the ideational trace, retained in the memory of participants and witnesses.[64] The

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[63] Ienca & Andorno, 2017.

[64] Johnson, E. (2024). *Locard's exchange principle*. In EBSCO Research Starters: Science. EBSCO Information Services. https://www.ebsco.com/research-starters/science/locards-exchange-principle

dichotomy has structured forensic doctrine for over a century, but it presupposes that the ideational trace is accessible only mediately—through verbal testimony subject to memory distortion, deception, or refusal. The fifth-generation brain–computer interface paradigm dissolves this presupposition, generating the doctrinal need for a third trace category.

5.2. Instrumentally Registrable Ideational Trace (IRIT)

The authors advance a third doctrinal category: the *instrumentally registrable ideational trace* (IRIT). Like material traces, IRIT can be instrumentally recorded and used as evidence—registration occurs through a measuring device rather than through verbal mediation; it shares with the classical ideational trace the property of being located within the subject's cognitive sphere rather than at the crime scene. The IRIT thus occupies a structurally distinct position: it is an ideational trace registered materially. The doctrinal consequence is that classical evidentiary rules developed for either pure category cannot be extended to the IRIT by analogy; an autonomous evidentiary doctrine is required.

Two neuroscientific findings substantiate the autonomy of this category. First, recognition memory is supported by a mid-frontal old/new effect manifesting as positive ERP differences peaking approximately 400 milliseconds after stimulus onset, distinct from a parietal old/new effect peaking around 600 milliseconds.[65] Second, dual-process theory distinguishes recollection—episodic recall of contextual detail bound to the item—from familiarity—generalised recognition without specific recall, with separable electrophysiological signatures in time and topography.[66] The forensic implication is that the IRIT is not unitary; it is itself stratified into recollection-class and familiarity-class signatures with different evidentiary weights.

5.3. Attributive Gap

The second principal proposition concerns the discontinuity between the technological registration of recognition and the legal attribution of guilty knowledge. The authors term this discontinuity the *attributive gap*. The gap is generated by the fact that recognition of a stimulus indicates only that the subject's memory contains representations of that stimulus; it does not indicate the source from which those representations were acquired. A suspect's brain may recognise a crime-scene image because the suspect was present as the perpetrator, present as a witness, present as the victim, present as a first responder, or because the suspect was exposed to the image through media coverage, investigative leakage, prior interrogation, or even legitimate familiarity with the location.

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65 Curran, T., et al. (2006). Combined pharmacological and electrophysiological dissociation of familiarity and recollection. *Journal of Neuroscience, 26*(7), 1979–1985.

66 Curran, T., & Cleary, A. M. (2003). Using ERPs to dissociate recollection from familiarity in picture recognition. *Cognitive Brain Research, 15*(2), 191–205.

The attributive gap is therefore a triple problem: a problem of source attribution (where did the representation come from?); a problem of legal qualification (does this source establish criminal participation?); and a problem of evidentiary weight (how much probative force can be assigned to recognition in the absence of source determination?). No generation of protocols has solved this problem, and the gap is not merely operational but structural—it cannot be closed by improvements in signal processing alone.

5.4. IRIT—Attributive Gap Coupling

The two propositions are doctrinally coupled. The IRIT establishes the autonomy of the new evidentiary object; the attributive gap establishes the limits of inferential extension from the object to a legal conclusion. Together they yield a normative principle that the authors formulate as the *contributory rule*: an IRIT registered with methodological validity may serve as one element of a broader evidentiary configuration but cannot independently establish criminal participation. The contributory rule is the forensic foundation of the two-tier admissibility regime developed further in this article.

5.5. Procedural Integration into Investigative Action

The Criminal Procedure Code of the Republic of Uzbekistan does not currently recognise neuroexpertise as an autonomous form of investigative action. Three integration pathways are doctrinally available. The first pathway treats neuroexpertise as a sub-form of forensic-medical or forensic-psychiatric examination; this path understates the autonomy of the IRIT and conflates cognitive registration with mental-health assessment. The second pathway treats neuroexpertise as an extension of forensic-psychophysiological expertise (the polygraph framework), already established in the post-Soviet doctrinal tradition; this path captures the procedural form but understates the technological discontinuity between autonomic and cortical registration. The third pathway—the path advocated here—recognises neuroexpertise as an autonomous category, occupying a structural position in the system of forensic examinations parallel to dactyloscopic, ballistic, and trace-evidence examinations.

5.6. Consent Regime

Because the IRIT registers cognitive content, the consent regime governing neuroexpertise must be more demanding than that governing material-trace examination. The Constitution of Uzbekistan prohibits medical and scientific experiments without consent, and this rule extends doctrinally to instrumental cognitive examination. Three concrete features must structure the consent regime: pre-examination disclosure of the methodological limits of the procedure, including documented countermeasure-vulnerability; the right of withdrawal at any stage of the examination without adverse procedural consequence; and judicial supervision of the consent procedure in particularly grave cases, where the risk of structural coercion is highest.

5.7. Evidentiary Status of the Neuroexpert's Conclusion

The conclusion of the neuroexpert is—by virtue of the attributive gap—a conclusion about the cognitive registration of stimuli, not about criminal participation. The procedural form of this conclusion must therefore mirror its evidential limits. The expert's report must explicitly distinguish three findings: the methodological adequacy of the registration; the registered cognitive response, classified as recognition, non-recognition, or indeterminate; and—critically—the express disclaimer that the registered response is compatible with multiple acquisition sources, only one of which is criminal participation. This procedural form aligns with the framework according to which admissibility is a complex legal, factual and scientific question rather than an inherent property of the technology.[67]

5.8. Judicial Gatekeeping Function

The admissibility of neuroexpertise in criminal proceedings imposes a gatekeeping function on the trial court. The Daubert framework—under which the trial judge serves as final arbiter on admissibility, considering testability, peer review, error rates, the existence of standards, and general acceptance—provides a structural model that the Uzbek system, currently underdeveloped relative to *Daubert*-type filtering, may adopt and adapt.[68] This requires dedicated procedural rules: a pre-trial admissibility hearing, the requirement of prior peer review of the methodology, and the right of cross-examination of the neuroexpert on the limits of the IRIT—attributive-gap coupling.

5.9. Special Status of Recognition versus Recollection Evidence

The dual-process model of recognition memory has a direct procedural implication. Familiarity-class IRIT—registration of a generalised recognition response—establishes only that the subject's memory contains some representation of the stimulus; it does not establish the specific episodic recall of crime-relevant content. Recollection-class IRIT—registration of a specific episodic recall signature—has proportionally greater evidentiary weight. The procedural rules governing neuroexpertise must distinguish these two classes in the formulation of the expert's findings, in the structure of cross-examination, and in the weight that the trier of fact may assign.

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[67] Murphy, E. R. D., & Rissman, J. (2020). Evidence of memory from brain data. *Journal of Law and the Biosciences, 7*(1), lsaa078.

[68] *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993). Justia U.S. Supreme Court Center.

5.10. Doctrinal Implications

The forensic-criminalistic and procedural analysis converges on five operational requirements: doctrinal recognition of the IRIT as an autonomous trace category; explicit doctrinal articulation of the attributive gap as a structural limit on inferential extension; integration of the contributory rule into the evidentiary doctrine of the Criminal Procedure Code; recognition of neuroexpertise as an autonomous category of forensic examination; and the strengthening of the judicial gatekeeping function. These five requirements form the criminalistic-procedural architecture on which the institutional model—the Uzbek five-tier model—is constructed.

6. The Uzbek Five-Tier Model

6.1. Architectural Logic of the Model

The forensic-procedural architecture proposed for the Republic of Uzbekistan is structured as five interlocking layers: (i) the constitutional, (ii) the statutory regulatory, (iii) the procedural layer of the Criminal Procedure Code, (iv) the institutional layer of certified neuroexpertise, and (v) the regional implementation layer of the Samarkand Process. Each tier resolves a specific governance gap; together they constitute a coherent normative architecture for the integration of neurotechnology into national criminal justice within the human-rights framework established by the Samarkand Recommendation.

6.2. Constitutional Layer

The Constitution of the Republic of Uzbekistan, as amended in 2023 by referendum, already supplies the constitutional anchors for neuroprotective doctrine: personal inviolability, the inviolability of private life, the protection of personal data, and the prohibition of medical and scientific experiments without consent. The authors argue that the constitutional layer requires no formal amendment for the integration of neurocriminalistics; rather, it requires authoritative interpretive consolidation through a plenary ruling of the Constitutional Court linking these provisions to the specific question of cognitive instrumental access. This interpretive route is doctrinally faster than constitutional amendment and avoids the political risks associated with reopening the constitutional text.

6.3. Statutory Regulatory Layer

The statutory layer must integrate three existing normative instruments: the Law on Personal Data, the Law on Cybersecurity, and the recent Law No. LRU-1115 on Artificial Intelligence, which prohibits state bodies from relying exclusively on AI-generated conclusions in decisions affecting human rights and freedoms.[69] The

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[69] Gulyamov, S. S., & Rustambekov, I. R. (2026). Ethical aspects of AI regulation for higher education. *Legal Issues in the Digital Age, 7*(1), 49–70.

authors develop three statutory innovations: explicit qualification of neural data as a special sensitive-data category within the Personal Data framework; integration of neurodata-protection requirements into the cybersecurity strategy adopted by Presidential Decree No. 38 of March 10, 2026;[70] and the application of the human-oversight principle of LRU-1115 to neuroexpertise as an analytic process that may not autonomously determine criminal liability.

6.4. Procedural Layer: The Two-Tier Admissibility Regime

The procedural layer is the core of the model. The authors design a *two-tier admissibility regime* that resolves the tension between investigative effectiveness and the protection of human rights through differentiated procedural status. The first tier—*orienting application*—permits the use of neurotechnology at the stage of operational-investigative activity without procedural status as evidence. In this tier, the IRIT functions as an investigative lead: it may direct further inquiry, exclude unsupported hypotheses, or corroborate other evidentiary material, but cannot be cited in court. The second tier—*procedural application*—admits neuroexpertise as a forensic examination in particularly grave categories of offences, only with judicial authorization, as well as subject to the contributory rule explained above. This tier-based structure recognises that the human-rights framework contracts as procedural consequences expand: the more probative weight assigned to the IRIT, the more demanding the consent and supervision regime must be.

6.5. Institutional Layer: Neuroexpertise as Autonomous Forensic Examination

The institutional layer requires the formal recognition of neuroexpertise as an autonomous category of forensic examination, distinct from forensic-medical, forensic-psychiatric, forensic-psychological, and forensic-psychophysiological examinations. The authors outline three institutional features: a national register of certified neuroexperts trained according to standardised methodological protocols; a specialised review chamber within the existing forensic examination system to address methodological disputes in individual cases; and mandatory continuous-education requirements aligned with the international evolution of the field, particularly with the methodological refinements anticipated by 2030. The autonomy of this category is essential because conflation with adjacent forms of expertise either understates the technological discontinuity (in the case of psychophysiological assimilation) or overstates the clinical character of the examination (in the case of psychiatric assimilation).

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[70] Abdushukurov, N. (2026, March 17). *Uzbekistan adopts national cybersecurity strategy to 2030*. Nurilla Abdushukurov – Insights & Updates. https://www.nurilla.com/insights/uzbekistan-cybersecurity-strategy-2030.html

6.6. Regional Implementation Layer: The Samarkand Process

The fifth layer addresses the institutional gap identified earlier in the article. The authors advance the Samarkand Process—by structural analogy with the Helsinki Process on European security and the Bologna Process on higher education—as the institutional mechanism for the regional implementation of the Samarkand Recommendation across the post-Soviet space and Central Asia. The Process is structured around four institutional outputs: a regional declaration aligned to the Samarkand Recommendation; the harmonisation of statutory neurodata-protection regimes across participating jurisdictions; a regional registry of certified neuro-forensic experts enabling cross-border methodological recognition; and a periodic review mechanism reporting to UNESCO. Uzbekistan's geopolitical position as the territorial origin of the Samarkand Recommendation provides the legitimacy required to host this process.

6.7. Implementation Sequence

The five layers must be implemented sequentially. Constitutional interpretive consolidation occurs prior to statutory amendment; statutory amendment is followed by procedural-code revision; procedural-code revision precedes institutional certification; and institutional certification is followed by the regional initiative. The authors recommend a five-year implementation horizon (2026–2030) calibrated to the parallel development trajectories of the technology and the international normative framework. This horizon aligns with the 2030 strategic targets articulated in the Cybersecurity Strategy and in the AI development roadmap, ensuring institutional convergence across adjacent domains of digital governance.

6.8. Integration with the BRICS Jurisdictions

The five-tier model is designed to be functionally compatible with the BRICS regulatory architectures examined in the article. Compatibility is achieved through three structural choices: the contributory rule converges with the corroboration requirements observable across BRICS practices; the autonomous-category recognition of neuroexpertise mirrors the structural innovation in Chinese ethics governance and Brazilian sub-national constitutional incorporation; and the Samarkand Process, while regionally anchored in the post-Soviet space, is designed to be open to participation by interested BRICS jurisdictions seeking institutional coordination on the Samarkand Recommendation.

6.9. Architectural Resolution

The Uzbek five-tier model resolves the cross-cutting tensions identified in section 4 of this article through architectural differentiation rather than substantive trade-off: investigative effectiveness operates within the orienting tier, mental-privacy protection within the procedural tier; scientific progress proceeds within the institutional tier, the precautionary principle within the constitutional and regulatory tiers; national sovereignty is preserved within the procedural and institutional tiers, transnational coordination achieved within the Samarkand Process tier. The model thus translates the Samarkand Recommendation from international soft law into a coherent national architecture that both respects human rights and equips the criminal-justice system for the technological transition examined in the next section's prospective analysis.

7. Prospects for Development to 2030

The five-year horizon to 2030 will determine whether neurotechnology enters criminal procedure as a regulated forensic instrument or as an unregulated investigative practice. Industry projections estimate annual growth of 15–18 % in the global brain–computer interface market through 2030, with venture investment exceeding USD 1.6 billion in the 2025–2026 cycle alone.[71] Commercialisation of consumer-grade implants is expected as early as 2030,[72] generating a regulatory window of approximately five years within which national normative architectures must be put in place.

The technological trajectory points toward three convergent capabilities. First, non-invasive or minimally invasive portable wireless technologies are projected to record signals simultaneously from 50,000 to 100,000 neurons, with detection at the dendritic and axonal level.[73] Second, machine-learning architectures specialised in neural-signal decoding are reducing the gap between laboratory accuracy and field application. Third, the integration of brain–computer interface methods with artificial intelligence raises forensic-doctrinal challenges that the Law No. LRU-1115 framework—prohibiting exclusive reliance on AI-generated conclusions in decisions affecting human rights—already partially anticipates. The Uzbek five-tier model is structured to absorb each of these technological developments without doctrinal displacement.

The institutional trajectory will be shaped by three parallel processes. The implementation of the Samarkand Recommendation across UNESCO Member States will generate national normative experiments whose comparative evaluation will gradually consolidate transnational best practices. The continued evolution of BRICS regulatory architectures—particularly the Brazilian PEC 29 and the Chinese ethics governance framework—will provide doctrinal models for consideration

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71 BCI Intelligence. (2026). *State of BCI: 2026 annual industry report*. bciintel.com. https://bciintel.com/state-of-bci-2026/

72 GlobalData Healthcare. (2025, August 13). *Brain-computer interfaces are closer than you think*. Clinical Trials Arena. https://www.clinicaltrialsarena.com/analyst-comment/brain-computer-interfaces-closer/

73 Gaudry, K. S., et al. (2021). Projections and the potential societal impact of the future of neurotechnologies. *Frontiers in Neuroscience, 15*, 658930.

within the post-Soviet space. The development of the Samarkand Process itself, if institutionalised on the timetable proposed in § 6.7, will deliver a regional declaration by 2027 and an operational neuroexpertise registry by 2029.

Three risk vectors must be monitored across the period. The first is regulatory lag: the gap between the deployment of consumer neurotechnology and the development of criminal procedural regulation. The second is institutional capture: the possibility that early operational experience accumulates within security agencies before judicial supervision is normatively established, generating path dependencies that subsequent reform cannot easily reverse. The third is methodological hardening: the premature crystallisation of protocols whose laboratory accuracy does not survive field deployment, with consequent miscarriages of justice that may delegitimise the entire trajectory of forensic neurotechnology.

The strategic conclusion is that the period 2026–2030 is the determinative window for normative architecture. Decisions taken or deferred in this period will structure the role of neurotechnology in criminal justice for the subsequent generation. The Republic of Uzbekistan, by virtue of its position as the territorial origin of the Samarkand Recommendation and its active development of adjacent digital-governance instruments, is uniquely positioned to lead this normative work—provided that the five-tier model proposed in the article is implemented within the implementation horizon specified in that section.

Conclusion

The fifth-generation brain–computer interface paradigm transforms the foundational dichotomy of forensic science by rendering ideational traces susceptible to instrumental registration. The adoption of the UNESCO Recommendation on the Ethics of Neurotechnology in Samarkand on November 11, 2025 establishes the first global normative framework for this technological transition. The conjunction of these two developments creates a determinative window—extending to 2030—within which national criminal justice systems must develop coherent forensic-procedural architectures or accept the emergence of unregulated investigative practices. The article has designed a doctrinal, normative, and institutional architecture for the Republic of Uzbekistan designed to seize this window before it closes.

The doctrinal contribution consists of two coupled propositions. The instrumentally registrable ideational trace is conceptualized as a third category of forensic trace, irreducible to either the material or the classical ideational, and stratified into recollection-class and familiarity-class signatures with differentiated evidentiary weights. The *attributive gap* identifies the structural discontinuity between the technological registration of recognition and the legal attribution of crime-relevant knowledge, and yields the *contributory rule* that an instrumentally registered trace cannot independently establish criminal participation. Together these propositions ground an autonomous evidentiary doctrine that classical material-trace and ideational-trace rules cannot supply.

The normative and institutional contribution consists of three coupled propositions. The *two-tier admissibility regime* differentiates orienting application at the operational-investigative stage from procedural application as neuroexpertise restricted to particularly grave offences, resolving the tension between investigative effectiveness and human-rights protection through an architectural rather than substantive trade-off. The recognition of *neuroexpertise as an autonomous category* of forensic examination, distinct from forensic-medical, forensic-psychiatric, forensic-psychological and forensic-psychophysiological examinations, provides the institutional framework within which the procedural tier operates. The *Samarkand Process*, by structural analogy with the Helsinki and Bologna Processes, supplies the regional implementation mechanism through which the post-Soviet space and Central Asia can coordinate the implementation of the Samarkand Recommendation.

These five propositions, integrated within the Uzbek five-tier model, establish the doctrinal, normative and institutional foundations of neurocriminalistics in the Republic of Uzbekistan. Their implementation during the 2026–2030 period would consolidate Uzbekistan's geopolitical position as the territorial origin of the Samarkand Recommendation into substantive regional leadership in shaping international neuroforensic standards. The fifth-generation brain–computer interface era requires that criminal justice be neither captured by the technology nor closed to its legitimate exonerative potential; the architecture proposed here is calibrated to this dual requirement.

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