UBSN
University Research Facility in Behavioral and Systems Neuroscience
神經科學中心實驗室

NEWSLETTER
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Prof. Lei Sun Team "Nature Communications": Nanobubble-actuated ultrasound neuromodulation selectively shapes behavior in mice

Precise neuromodulation is essential for understanding and treating neurological disorders. Ultrasound (US)neuromodulation has emerged as a promising approach due to its non-invasive nature and deep-tissue penetration. However, conventional ultrasound faces inherent limitations in spatial precision due to acoustic diffraction and skull interference, making it challenging to target specific brain regions accurately.

Prof. Lei Sun from the Department of Biomedical Engineering at The Hong Kong Polytechnic University, addresses these challenges by introducing a novel approach utilizing polyethylene glycol (PEG)-modified Gas Vesicles (PGVs). These specially engineered nanobubbles significantly enhance the precision and efficacy of ultrasound stimulation, enabling targeted neuronal activation at sub-millimeter resolution.

In Prof. Sun's study, his team demonstrated that PGVs-mediated ultrasound stimulation effectively activates specific regions of the mouse motor cortex, producing precise limb movements confirmed by electromyography (EMG) recordings. This enhanced spatial precision allowed them to stimulate highly targeted cortical regions to evoke reliable, reproducible responses. Furthermore, they explored deeper brain structures, particularly the striatum, which plays a critical role in motor control and behavior. By selectively stimulating distinct subregions within the striatum, they induced specific and reproducible behaviors, such as rotational movements (Figure 1a) or freezing of gait (Figure 1b), simply by varying the PGVs injection site.

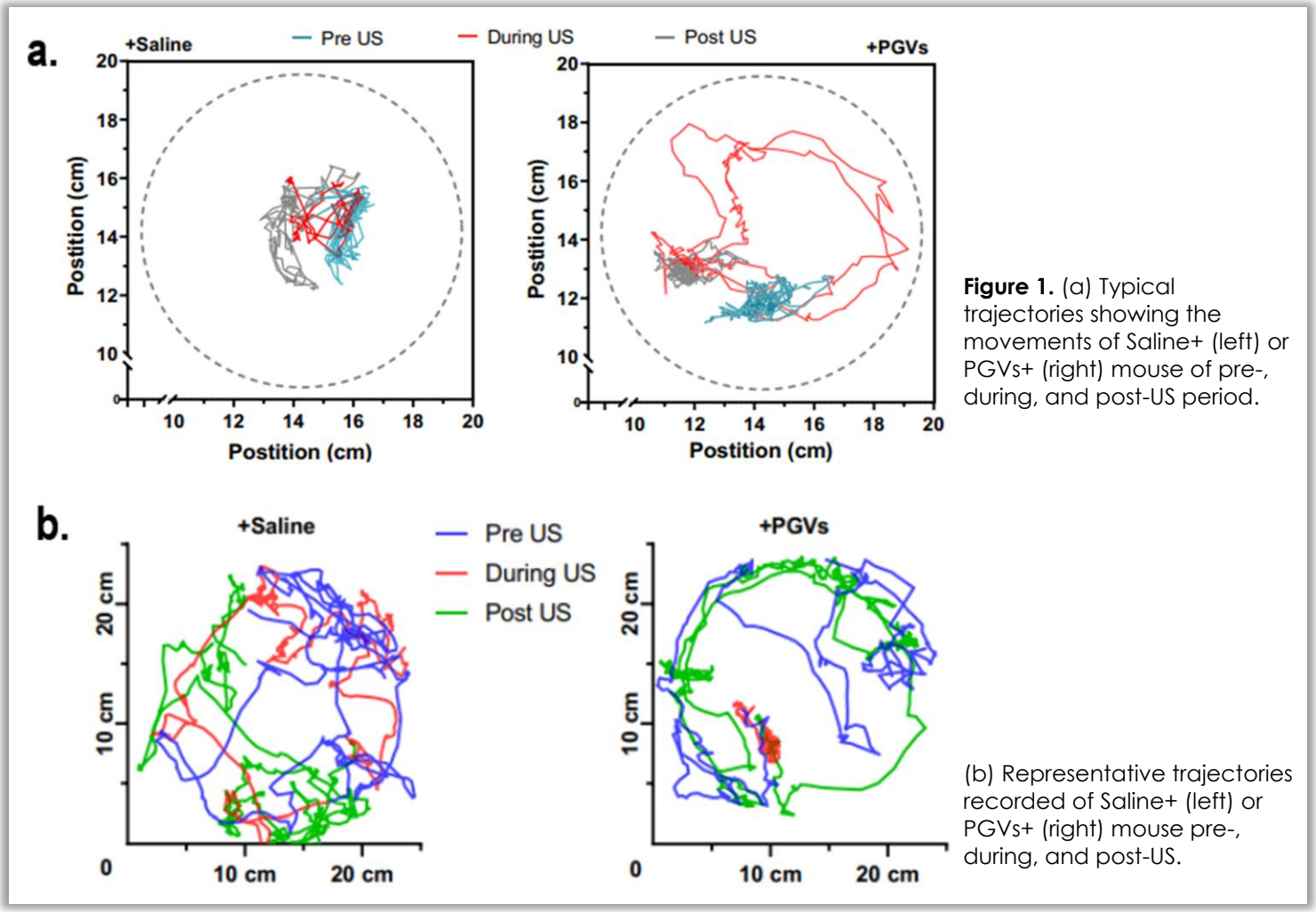

Figure 1. (a) Typical trajectories showing the movements of Saline+ (left) or PGVs+ (right) mouse of pre-, during, and post-US period.

(b) Representative trajectories recorded of Saline+ (left) or PGVs+ (right) mouse pre-, during, and post-US.

Investigating the underlying mechanisms, Prof. Sun's team found that PGVs-assisted ultrasound induces rapid, repeatable, and reversible calcium influx in neurons, primarily mediated through mechanosensitive ion channels. These ion channels are crucial for converting mechanical stimuli into calcium signals within neurons. By effectively leveraging these natural cellular pathways, our approach ensures physiological compatibility and reduces potential side effects compared to other invasive stimulation methods.

An additional aspect of their research explored the therapeutic potential of this technique. Targeting serotonergic neurons in the dorsal raphe nucleus (DRN), a brain region heavily involved in mood regulation, Prof. Sun's team successfully alleviated depressive-like behaviors in mice models. This finding highlights the significant potential for PGVs-mediated ultrasound stimulation to be applied therapeutically in treating neurological disorders, providing a non-invasive, targeted alternative to conventional treatment methods.

One of the key advantages of their approach is that it requires no genetic modification of the neurons, unlike methods such as optogenetics or chemogenetics. These characteristic positions their technique as highly promising for clinical translation, offering safe and effective neuromodulation without genetic interventions.

The corresponding author of this paper is Prof. Lei Sun, from the Department of Biomedical Engineering at The Hong Kong Polytechnic University. Xuandi Hou and Jianing Jing contributed equally as first authors.

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Prof. Lei SUN

Professor

Department of Biomedical Engineering

Publication related to the article:

- Hou X, Jing J, Jiang Y, et al. Nanobubble-actuated ultrasound neuromodulation for selectively shaping behavior in mice. Nature Communications. 2024;15:2253. DOI: 10.1038/s41467-024-46461-y. https://www.nature.com/articles/s41467-024-46461-y

PolyU research reveals sustained obesity may accelerate brain ageing

Prof. Anqi QIU, Professor of the Department of Health Technology and Informatics at The Hong Kong Polytechnic University (PolyU) and Global STEM Scholar, is researching the intricate neural connections between obesity and cognitive health in middle-aged and older adults to enhance our understanding of this complex issue. Prof. Qiu's research conducts a longitudinal analysis using data from the UK Biobank to identify five distinct obesity trajectories. The study reveals that individuals in the decreasing trajectory exhibit minimal negative impacts on brain structure and cognition compared to those in the low-stable group. In contrast, increasing, moderate-stable, and high-stable trajectories are linked to progressive impairment in brain structure, functional connectivity, and cognitive performance.

The UBSN at PolyU is equipped with an advanced whole-body Magnetic Resonance Imaging (MRI) for research

The adverse effects manifest differently across brain regions, began in the fronto-mesolimbic regions for the increasing trajectory, extended to parietal and temporal regions in the moderate-stable group, and ultimately led to widespread brain abnormalities in the high-stable group, with sustained obesity potentially accelerating brain ageing. The research underscores the importance of managing obesity over the long term to preserve brain health, suggesting that persistent obesity could serve as a biomarker for assessing brain ageing. Prof. Qiu highlights the significance of weight control in improving brain health amid a growing ageing population and increasing neurodegenerative diseases. Future plans involve exploring biological pathways affecting brain and body health using multi-omics approaches. Published in Nature Mental Health, the study utilized data from the UK Biobank with over 500,000 participants aged 40 and above, showcasing the extensive impact of obesity on brain and cognitive health.

Read more:

https://www.polyu.edu.hk/media/media-releases/2025/0410_polyu-research-reveals-sustained-obesity-may-accelerate-brain-ageing/

https://www.nature.com/articles/s44220-025-00396-5#Abs1

Introducing UBSN's equipment update

TMS with EEG close-loop system

An advanced neurostimulation setup merges TMS with real-time EEG monitoring. EEG tracks brain activity continuously, shaping the timing and intensity of TMS pulses. Unlike open-loop TMS, this closed-loop system tailors stimulation to the brain's real-time state, enhancing precision in research and clinical uses like cognitive enhancement or treating brain disorders.

Specifications:

A complete real-time, brain state-dependent closed-loop TMS-EEG research system designed for advanced neuromodulation studies, with full MATLAB/Simulink integration and compatible accessories.

Real-Time Interface & Data Handling:

- Real-time signal analysis and TMS trigger interface
- High-precision, multi-channel EEG signal detection
- EEG data streaming latency <1.5 ms via user datagram protocol (UDP)

Supports personalized TMS paradigms with:

- Phase and amplitude targeting
- Oscillation detection
- Customizable spatial and frequency filters
- Precise timing access and TTL trigger output

TMS Stimulator Capabilities:

- Stimulation patterns: Single pulse, rTMS, TBS (2–5 pulses/train), Dual, Twin, and Power modes.
- Waveforms: Biphasic, Monophasic, Half-sine (standard and power modes).

EEG System:

- 64-channel TMS-compatible EEG system
- Sample rate: 5 kHz
- Supports bilateral signal acquisition (left/right hemispheres)
- Real-time detection of phase and amplitude (Theta, Alpha, Beta)
- TTL outputs

Officer-in-charge:

Dr. Tommy Lam (lh-tommy.lam@polyu.edu.hk)

SevenDirect SD20 pH Meter

Specifications:

- Straight to the point: SD20 pH meter with all-rounder InLab Expert-Pro ISM pH/temperature sensor featuring automatic sensor recognition. The kit includes an efficient electrode arm and pH buffer sachets for initial calibration.
- Mastered in no time: Large color touchscreen provides direct measurement and easy data entry. Instructions guide users through the sensor calibration process.
- Tracks your records: The instrument stores data like timestamp, sample and sensor ID with every measurement and prints or exports records automatically.
- Tough enough: Closed connector compartment and replaceable cover keep the instrument safe from dust and spills, even with sensors attached (IP54 in-use).

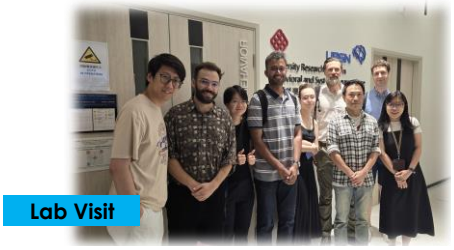
Officer-in-charge:

Dr. Patrick Yeung (patrick-kk.yeung@polyu.edu.hk)

Recent events at UBSN

In July, UBSN had the honor of welcoming visitors from The University Medical Center of the Johannes Gutenberg University Mainz and students from Tongji University.

We held a Capacity Building Scheme seminar and workshop with Prof. Charlotte Stagg who gave us a seminar titled: "Using Magnetic Resonance Spectroscopy to understand human neurophysiology".



Visitors from The University Medical Center of the Johannes Gutenberg University Mainz

Students from The Tongji University

Magnetic Resonance Spectroscopy Seminar (Capacity Building Scheme)
Speaker: Prof. Charlotte Stagg

Magnetic Resonance Spectroscopy Workshop (Capacity Building Scheme)
Instructor: Prof. Charlotte Stagg

In August, UBSN hosted a workshop for secondary school students from the Invent Your Own Future (IYOF) Neuroscience Summer Camp.

In early September, UBSN warmly welcomed teachers and students from Beijing Normal University and South China Normal University to visit our facility.

Students from the Invent Your Own Future (IYOF)

Teachers and students from Beijing Normal University and South China Normal University

At UBSN, we hope to bring users useful knowledge regularly and inspire more innovative research at PolyU. If you have any requests or suggestions on an equipment, drop us a message!
For more UBSN news and events, visit our website:
https://www.polyu.edu.hk/ubsn/news-and-events/

Upcoming Events at UBSN

UBSN regularly hosts seminars and workshops featuring UBSN equipment, let us know if you have any particular areas of interests!

Starting the next bimester, UBSN will host seminars and workshops featuring human behavior equipment such as TMS, fNIRS, EEG, etc. In September, UBSN will organize several workshops, including a closed-loop TMS-EEG workshop and an EEG & NeuroScan CURRY9 workshop.

Stay tuned by checking out our website:
https://www.polyu.edu.hk/ubsn/news-and-events/

Follow on Instagram:

@UBSN.POLYU

Have any questions? Interested in using our equipment? Please contact us!
Website: https://www.polyu.edu.hk/ubsn **E-mail: ubsn.enquiry@polyu.edu.hk**