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PRESS RELEASE

New Findings on Information Processing in the Brain

International research team discovers narrowings in the tube-shaped extensions of nerve cells

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Bonn, September 14 – Neurons receive thousands of signals via tree-like extensions called dendrites. Until now, these dendrites were thought to be relatively smooth cables that conduct electrical signals to the cell body. An international research team led by the University Hospital of Bonn (UKB), the University of Bonn, and the DZNE has now determined that this picture is incomplete. Using various advanced microscopy techniques, it has identified tiny, previously overlooked constrictions along the dendrites. These newly discovered structures, which the researchers call dendritic shaft constrictions, are only a few hundred nanometers wide – about 500 to 1,000 times thinner than a human hair – and occur in various types of neurons in both mouse and human brains. The study results have now been published in the journal *Science Advances*.

Small tree-like projections, known as dendrites, function as the neurons' receiving antennas. They pick up electrical signals from other nerve cells and relay this information to the cell body, with dendritic spines serving as contact points for other neurons. In this way, dendrites enable communication within the nervous system. Since they can alter their shape and the number of their branches to store new information, they also play a central role in what is known as neural plasticity and, consequently, in learning processes and memory.

The structure of dendrites is closely linked to their function. Dendritic spines, with their bulbous heads connected to the dendrite by a thin neck, are typical examples of this. With diameters ranging from a few tens to a few hundreds of nanometers, the necks of the spines form compartments that are essential for function and plasticity. In contrast, dendrite shafts are traditionally interpreted as smooth, continuous cables.

"While dendritic spines have long been known due to their prevalence, the constrictions in shaft diameter that we discovered have not been documented before. Another factor was that the diameter of these constrictions ranges from a few tens to a few hundred nanometers, which is below the resolution limit of conventional light microscopy," says first author Dr. Tony Kelly, a postdoc in Prof. Heinz Beck's research group at the Institute for Experimental Epileptology and Cognitive Research of the UKB and of the University of Bonn. "Even in high-resolution electron microscopy datasets, such local diameter variations may have been regarded until now as random irregularities rather than biologically significant structures."

In collaboration with numerous experts in high-resolution microscopy, including Prof. Dr. Ulrich Kubitscheck at the Clausius Institute for Physical and Theoretical Chemistry at the University of Bonn and Prof. Dr. Valentin Nägerl at the Institute of Anatomy and Cell Biology at the University of Göttingen, the research team was able to use multiple methods to identify localized constrictions in the diameter of the dendritic shaft, which they refer to as dendritic shaft constrictions (DSC). Using a combination of high-resolution imaging techniques, including expansion microscopy, STED (Stimulated Emission Depletion) microscopy, scanning probe microscopy, and serial electron microscopy, they demonstrate that dendrites in both mouse and human neurons exhibit localized diameter constrictions in the nanoscale range along their shafts. Computer simulations and experiments suggest that these constrictions can divide the dendrites into small electrical compartments. Signals arriving beyond a constriction can become stronger locally, while they are transmitted less effectively to the cell body. This also promotes the activation of NMDA receptors, which are important for changes in synaptic strength and for learning processes.

"Our findings therefore reveal a previously unrecognized structural feature that may allow individual dendrites to process information locally rather than merely relaying it," says last author Prof. Beck, who is a member of the ImmunoSensation Cluster of Excellence3and the Transdisciplinary Research Area (TRA) "Life & Health" at the University of Bonn. "Dendritic shaft constrictions could represent a new fundamental element in how neurons perform complex computations, although their precise biological role and how they are formed remain to be determined."

Participating Institutions: In addition to the UKB, DZNE, and the University of Bonn, Ariel University (Israel), the Université de Bordeaux (France), the University of Otago (New Zealand), Cincinnati Children's Hospital Medical Center and the University of Cincinnati (USA), as well as RWTH Aachen University and the University Medical Center Göttingen, participated in the study.

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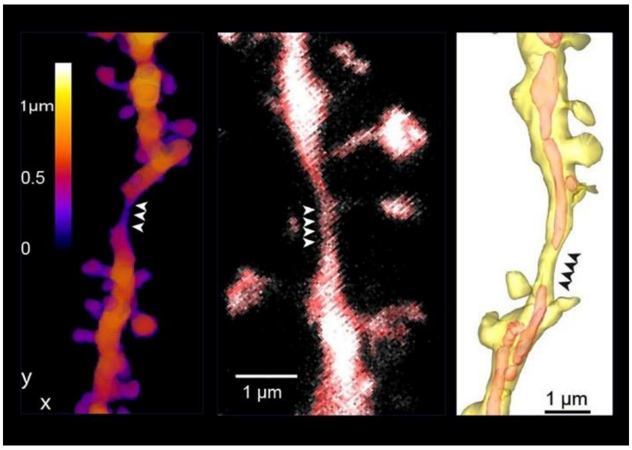

Caption: New Findings on Information Processing in the Brain:
Examples of Dendritic Shaft Constrictions (DSCs) imaged used high resolution microscopy techniques, expansion microscopy (left), STED (middle) and electron microscopy (right). Arrowheads indicate the position of DSCs.
Picture credits: University Hospital Bonn / Tony Kelly

Caption: Prof. Heinz Beck
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About the University Hospital Bonn: As one of Germany’s leading university hospitals, Bonn University Hospital (UKB) combines excellence in medical care and research with high-quality teaching. Every year, UKB treats more than half a million outpatients and inpatients. Around 3,500 students are enrolled in medicine and dentistry, and over 600 individuals receive training in healthcare professions annually. With around 9,900 employees, UKB is the third-largest employer in the Bonn/Rhein-Sieg region. In the „*Focus* hospital rankings“, UKB is rated the top university hospital in North Rhine-Westphalia and has the second-highest case mix index (an indicator of treatment complexity) of all university hospitals nationwide. In 2025, UKB secured nearly €100 million in third-party funding for research, transfer, and teaching. For the fourth consecutive year, the F.A.Z. Institute recognized UKB as both “Germany’s Training Champion” and “Germany’s Most Desirable Employer.” For current figures and further information, please refer to the annual report at: geschaeftsbericht.ukbonn.de