

# News & views

## Neuroscience

# Brain rhythms on the border

Hugo J. Spiers

Oscillations in neuronal activity in the medial temporal lobe of the human brain encode proximity to boundaries such as walls, both when navigating while walking and when watching another person do so. **See p.420**

Approaching the edge of a towering cliff is an unnerving experience. Watching another person do so can be equally unsettling. Our brain's capacity to process these boundaries is important – not only for avoiding such dangers, but also for navigation in general, because borders that divide spaces can help to locate resources. For instance, a steep ravine might be risky to amble through, but also useful for locating food or friends. How does our brain keep track of such information? Stangl *et al.*<sup>1</sup> report on page 420 that brain rhythms at a particular frequency increase when navigating near boundaries. This rhythm is also present when watching another person navigate.

Our ability to navigate depends on regions in the brain's medial temporal lobe (MTL), such as the entorhinal cortex and hippocampus<sup>2</sup>. Neurons in these areas provide an internal signal similar to a 'you are here' marker on a map<sup>2</sup>, allowing other brain regions to associate experiences with space ('don't ever come back to this terrible bar', for instance). Some of these neurons specifically signal proximity to borders<sup>3,4</sup>.

Owing to the challenges of recording from neurons in humans while they are awake and mobile, much of our understanding of how borders are represented in the brain has come from rodents. For rats scurrying around, the activity of neurons that signal borders occurs alongside the theta oscillation – a rolling change in the overall electrical activity of the broader brain region, caused by the co-activity of many neurons. The theta oscillation occurs at a frequency of between 8 and 12 hertz (ref. 5).

In humans, insights have been gleaned from people with epilepsy awaiting neurosurgery, who have electrodes implanted into the MTL. Recordings of neuronal activity can be filtered to account for epileptic discharge, revealing

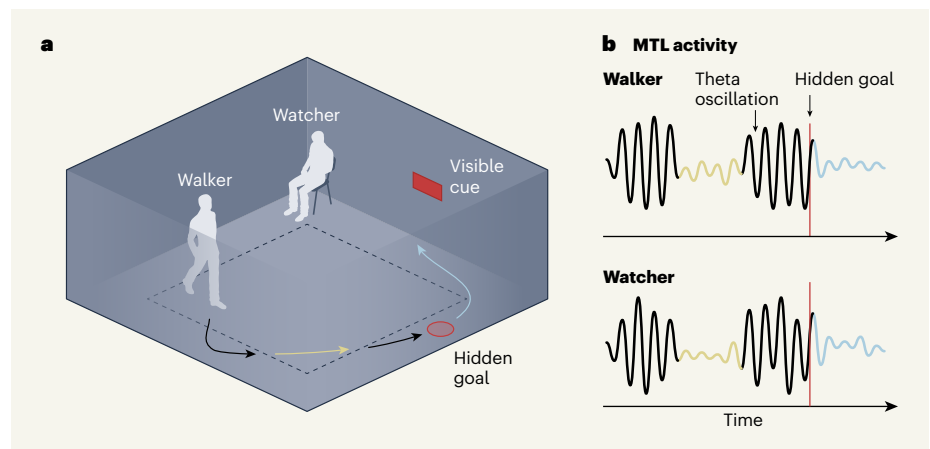
neuronal-activity patterns in deep brain structures. For example, experiments in which seated people navigate virtual environments have helped to reveal that theta oscillations in the human MTL are enhanced when the brain is encoding locations near boundaries<sup>6</sup>. However, it has been unclear whether such activity would occur when walking.

Stangl *et al.* overcame the challenge of recording from mobile humans using a wireless recording system<sup>7</sup>. Participants wearing the device had to alternate between navigating

to unmarked goal locations in a room and walking towards visually cued targets on the walls (Fig. 1a). The unmarked goal locations were learnt in an initial exploring phase, and participants then had to remember the positions of these goals in the experiment itself.

When participants were navigating towards an unmarked goal, theta oscillations in the MTL increased near walls, which marked the boundaries of the environment. This change was consistent across all participants, and continued both when approaching a wall or walking away from one. Notably, the oscillations were significantly weaker when simply walking to the cues on the wall, indicating that boundary-linked theta oscillations were strongest when memory was required to locate a target (Fig. 1b).

Evidence of boundary coding in the human MTL during walking is exciting, because much of our daily experience of navigating occurs when walking. Few studies have explored neural dynamics during this behaviour, because having participants walk brings added challenges. For instance, many other variables linked to self-motion, such as speed, might co-vary with boundary proximity, making it unclear whether boundaries are truly responsible for the results. Stangl and colleagues incorporated such metrics into their analysis,



**Figure 1 | Walkers and watchers share neuronal activity patterns.** **a**, Stangl *et al.*<sup>1</sup> designed an experiment in which one person explored a room while another watched. The walker navigated towards hidden goal locations they remembered from an earlier exploration phase, and walked towards visible goals marked on the walls (only one of each type of goal is shown here for simplicity, although the experiment used several). Dashed lines indicate the threshold over which the walker was considered to be near a wall for the analysis, and arrows indicate different phases of walking (towards a hidden goal while near a wall is in black, for instance). **b**, The authors analysed electrical activity in the brain's medial temporal lobe (MTL) in both walkers and watchers as the walkers navigated the room. They observed a strong oscillating pattern of brain activity called a theta oscillation in walkers as they navigated towards hidden goals – but only if they were also near walls. The oscillation was weak when navigating towards visible cues. Watchers showed the same activity patterns, implying that theta oscillations are part of our internal representation of space that helps track other people.

revealing that theta changes linked to boundaries seem to be independent of such variables, and also of eye-movement measures.

Nonetheless, it is possible that some unspecified variables linked to walking might drive the results. Stangl *et al.* addressed this concern in their next experiment. The authors took neural recordings from people watching someone else perform the same task. This key experiment revealed that MTL theta oscillations also increase when someone views another person navigating close to a wall. So, whether you are approaching a cliff edge or watching your friend do so, you are likely to have enhanced theta oscillations in your MTL. Because this response is shared between watching and walking, it seems more likely that the theta oscillations are related to an internal representation of space than to purely visual inputs or self-motion.

The discovery that human MTL structures encode information about other people parallels evidence for rat and bat neurons that encode the location of another animal<sup>18,9</sup>. More broadly, the discovery chimes with the idea of ‘mirror-like’ codes for observing and acting in the world<sup>10</sup>.

A key question is why theta oscillations increase near boundaries. Stangl *et al.* suggest that the change might originate from the greater demands for integrating information across brain networks when navigating. But it is unclear why network-integration demands would be higher near boundaries. Perhaps, when a person is close to a wall they are able to infer their location more precisely, and this increased precision leads to stronger theta oscillations. More research will be required to investigate this possibility and explore why researchers have not reported such results in rodents. Possible explanations are the experimental set-ups used to examine animals or the dominating influence of self-motion on theta in rodents<sup>2</sup>.

A broader question raised by Stangl and colleagues’ work is: how does the brain track the positions of other people in a space? Current models focus on how self-location is constructed<sup>2</sup>, but how visual inputs are used to map the position of other agents is an exciting area for future exploration. Stangl *et al.* had participants sit still while watching the other person navigate. But the dictates of everyday life mean we are often watching and walking at the same time. How might the locations of multiple agents be integrated with that of our own? It seems plausible that the brain constructs multiple distinct maps for locating ourselves, friends and foes in physical space, and links these with more-abstract maps of social networks and knowledge hierarchies<sup>11</sup>.

Several species, such as orcas, wolves and chimpanzees, are adapted for group hunting<sup>12</sup>. How their brains coordinate for this behaviour is unknown, but it now seems that the

MTL theta rhythm might be involved. Thanks to Stangl and colleagues, who have climbed over a technical cliff-edge, we can now see new horizons where exciting discoveries await.

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### Global health

# Gaps in measles-vaccine coverage mapped

**C. Edson Utazi & Andrew J. Tatem**

Precise maps of routine first-dose measles vaccinations show slowing progress around the world between 2010 and 2019, and large gaps in coverage in many places. Many countries are unlikely to achieve global 2020 coverage targets. **See p.415**

Improved access to childhood vaccines has been one of the biggest breakthroughs in public health in recent decades, as evidenced by the eradication of smallpox in 1980 and this year’s declaration of Africa as polio-free<sup>1</sup>. But for measles, the road towards elimination and eradication has been bumpy, despite the existence of a safe and cost-effective vaccine. Measles cases and deaths persist, particularly in low- and middle-income countries (LMICs; see [go.nature.com/37ra1bw](https://go.nature.com/37ra1bw)), where many

**“The maps uncover remarkable inequities in vaccine coverage, both within and between countries.”**

factors – from conflict to vaccine hesitancy and underfunding – continue to pose challenges to immunization. On page 415, a group called the Local Burden of Disease Vaccine Coverage Collaborators<sup>2</sup> provides evidence that targets for measles vaccination are in jeopardy, owing to major inequities in coverage, together with the slowdown, stagnation and regression of the coverage of routine first-dose measles vaccines between 2010 and 2019.

The authors used a mapping approach that facilitates the estimation of population-health

metrics in precise geographical areas – typically communities living in areas of 5 square kilometres. This approach to public health gained prominence following the launch of the United Nations Sustainable Development Goals in 2015, which call for improvements to a range of factors from health to education, leaving “no one behind”. Precise mapping means that, instead of designating large areas for health interventions, policymakers have a basis for targeting resources better to improve equity and impact. High-resolution maps that estimate various health and demographic indicators (such as population density, vaccination coverage, educational attainment and child mortality) are becoming increasingly available at a range of geographical and temporal scales, from country-level to continental and global maps, and from specific years to annual estimates spanning multiple years<sup>3–5</sup>.

This renaissance in mapping of health and demographic indicators is mostly being driven by an unprecedented increase in data availability and computing power over the past decade. Satellite images of Earth’s surface conditions, along with gridded data on a wide range of socio-economic factors, are enhancing our understanding of living conditions in even the remotest places in the world. In turn, these data are helping researchers predict the coverage of essential health services.