The scale of grid cell firing patterns is modulated by spatial uncertainty in rodent virtual reality

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Abstract

Medial entorhinal (mEC) grid cells display discrete firing fields organized in a regular hexagonal pattern (Fyhn et al., 2004). Although early studies indicated that the scale of the grid-pattern was constant between environments - supporting the notion that they represent a universal spatial metric (Hafting et al., 2005) - more recent work has demonstrated that grid scale is not static. For example, in response to environmental novelty grid patterns transiently expand (Barry et al., 2012) and on the vertical plane grid scale is permanently increased (Casali et al., 2019). These scenarios are characterised by reduced or unreliable spatial cues and previously we proposed that grid expansion was an adaptive response to elevated spatial uncertainty - computational simulations demonstrated that expansion of grid-patterns mitigated the reduction in accuracy resulting from reduced spatial information (Towse et al., 2014). We tested this hypothesis by recording grid cells from head-fixed mice running through distinct virtual reality environments characterised by differing levels of spatial uncertainty. Grid firing in these impoverished environments showed clear periodic patterns across trials, consistent with their activity in 2D real world environments. Moreover, in support of our hypothesis, we found that grid scale increased in the environments characterised by the highest levels of spatial uncertainty. Together, these findings suggest that the scale of grid-patterns are modulated to optimise the encoding accuracy of entorhinal networks.

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