Cortical topography of intracortical inhibition explains speed of decision making

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The functional consequences of the topographical arrangement of cortical maps of the body surface are still debated. To address these questions we used a tactile multiple-choice reaction time (RT) task which requires selecting a given finger out of all ten of both hands [1] In this task the distribution of RTs displays a striking inverted U-shape, where the RTs for the middle fingers of each hand are significantly slower. This effect is restricted to the condition of selection among all fingers as all fingers show identical RTs when tested in a dual choice task. To investigate a role of cortical topographies in the speed of the selection decision, we applied tactile coactivation [2-7], a stimulation protocol based on Hebbian learning to induce changes of the cortical hand representation through cortical plasticity. Changes in topography influenced RTs as after coactivating the right middle finger, RTs on this finger were significantly shortened resulting in the inverted U-shape distribution to almost disappear. This effect was restricted to the multiple choice task as no changes of RTs were observed in a dual-choice task. Accordingly, early stages of somatosensory cortical areas are involved in this task and their topographies play an important role in determining the speed of selection processes.

We used neural fields as an approach to population activation [8,9] with different subgroups of neurons coding for different fingers and interacting through Mexican-hat type interaction with recurrent excitation and lateral inhibition to account for our experimental results. Simulations show the inverted U-shape distribution of RTs as an emergent consequence of the lateral inhibition within cortical representational maps indicating a crucial role of interaction in the process of decision making. By weakening the strength of inhibition [10] we can model the influence of coactivation on the level of changes of cortical topography and its influence on RTs. Our model thus attributes the emergence of the inverted U-shape distribution and its modification through learning to lateral inhibition within cortical topography. While the role of cortical topographies for localization is straightforward, we provide evidence that interaction processes within cortical maps are also crucial for selection and thus functions related to decision making.

References

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