Spiking model for the interaction between action recognition and action execution

Mohammad Hovaidi Ardestani[1, 2], Martin Giese[1]
[1] Section Computational Sensomotorics, CIN & HIH, Department of Cognitive Neurology, [2] IMPRS for Cognitive and Systems Neuroscience, University Clinic Tübingen, Tübingen, 72076, Germany
E-mail: Mohammad.Hovaidi-Ardestani@uni-tuebingen.de

Action perception and the control of action execution are intrinsically linked in the human brain. Experiments show that the concurrent motor execution influences the visual perception of actions and biological motion (e.g. [1]). This interaction likely is mediated by action-selective neurons in the STS, premotor and parietal cortex. We have developed a model based on biophysically realistic spiking neurons that accounts for the observed interactions between action perception and motor planning. **Methods** The model is based on two dynamic representation levels (Fig. A), one modeling a representation of perceived action patters (vision field), and one representing associated motor programs (motor field). Both levels are modeled by recurrent spiking networks that approximate neural fields, where each field consists of 30 coupled neural ensembles, each consisting of 80 excitatory and 20 inhibitory adaptive Exponential Integrate-and-Fire (aEIF) neurons [2]. Within each field asymmetric recurrent connections between the ensembles stabilize a traveling pulse solution, which is stimulus-driven in the visual field and autonomously propagating in the motor field after initiation by a go-signal. Both fields are coupled by interaction kernels that results in mutual excitation between the fields of the traveling pulse propagate synchronously and in mutual inhibition otherwise. **Results** We used the model to reproduce the result of a psychophysical experiment that tested the detection of point-light stimuli in noise during concurrent motor execution [1]. The point-light patterns showed arm movements of the observer, which were synchronized with varying time delays with the executed movements. Compared to a baseline without concurrent motor execution, the detectability of the visual stimulus was higher for very small time delays between the visual stimulus and the executed arm movement, and it was lower when the observed movement was strongly delayed (> 300 ms) against the executed motor patterns (Fig. B). The same pattern arises from the detectability of the visual stimulus as predicted from our model, where we assumed that the level of neural activity (compared to a noise level) provides a measure for the detectability of the stimulus (Fig. C). **Conclusions** The proposed model, which is derived by simplification from physiologically-inspired neural models for action execution and motor planning, reproduces correctly the modulation of visual detection by the synchrony of the stimulus with executed motor behavior. Present work extends the model by a full visual pathway and an effector model, allowing for the simulation of a broader spectrum of experimental results.

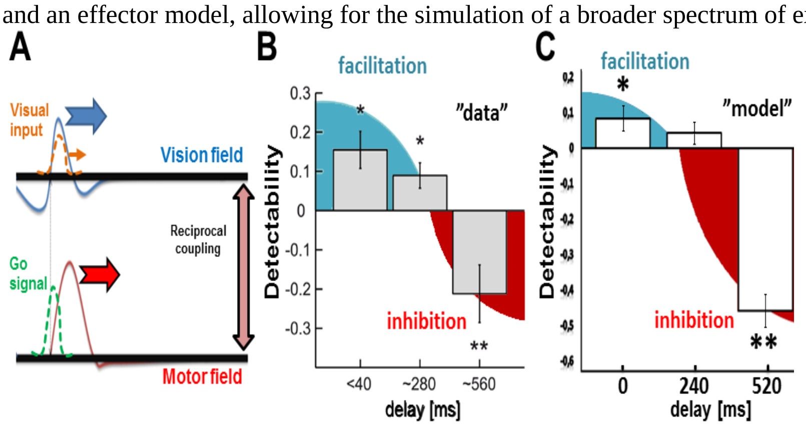

Figure: A Model architecture consisting of two coupled neural fields, implemented with biophysically realistic neurons. B Psychophysical results from [1] showing the dependence of the detectability of visual point-light stimuli in dependence of the delay between a visually observed and the concurrently executed action. C Simulated detectability derived from the model for the same experimental conditions.

Acknowledgements Supported by EC FP7-ICT-2013-FET-F/604102 (HBP), Fp7-PEOPLE-2011-ITN PITN-GA-011-290011 (ABC), FP7-ICT-2013-10/611909 (Koroibot), BMBF, FKZ: 01GQ1002A, DFG GI 305/4-1 + KA 1258/15-1.

References

1. Christensen A, Ilg W, Giese MA (2011) **Spatiotemporal tuning of the facilitation of biological motion perception by concurrent motor execution**. J Neurosci 31:3493–3499.
2. Brette R, Gerstner W (2005) **Adaptive Exponential Integrate-and-Fire Model as an Effective Description of Neuronal Activity**. J Neurophysiol 94:3637-3642.