Physiologically-inspired neural model for the visual recognition of social interactions from abstract and natural stimuli

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INTRODUCTION: Humans can perceive social interactions from natural as well as from highly impoverished stimuli, as shown by the classical experiments by Heider and Simmel. The neural circuits underlying this visual function remain completely unknown, and it has been suggested that the recognition of such stimuli is based on sophisticated probabilistic inference. We present a simple neural model that is consistent with the basic facts known about neurons in the visual pathway that recognizes social interaction from naturalistic as well as from abstract stimuli. In addition, we present an algorithm for the generation of stimulus classes of naturalistic and abstract interaction with full parametric control. Such stimuli are critical for electrophysiological experiments that clarify the underlying mechanisms. METHODS: The model consists of a hierarchical shape-recognition pathway with partial position invariance that is modelled using a deep neural network (VGG16), followed by a top-level architecture that computes the relative motion, speed and acceleration of moving agents in the scene, and which classifies the interactions. Relative position is computed using a gain-field mechanism.
The stimulus synthesis algorithm is derived from dynamic models of human navigation which are combined with methods for computer animation of quadrupedal animals. RESULTS: Classifying abstract stimuli consisting of moving geometrical figures generated by the algorithm, we found highly reliable classification of 12 action categories. The model reproduces this classification and in addition can recognize interactions from real movies showing interacting animals. The model proposes a variety of neuron classes, which can be used to guide the search for mechanisms in electrophysiology in ongoing physiological experiments. CONCLUSION: Simple neural circuits combined with learning are sufficient to account for simple forms of social interaction perception in real and artificial stimuli.

Acknowledgements:

HFSP RGP0036/2016, EC H2020 CogIMon ICT-23-2014 /644727, BMBF FKZ 01GQ1704, BW Stiftung NEU007/1, KONSENS-NHE, NVIDIA Corporation.

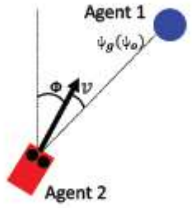

Fig. 1 Two interacting agents. Positions and body orientation generated by stimulus generator derived from human navigation models (Fajen & Warren, JEP: HPP, *29*(2), 343–362).

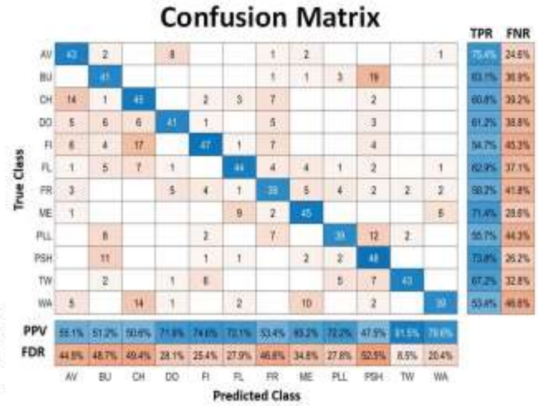

Fig. 2 Results from classification experiment showing that that 12 different interaction tyes generated by the algorithm can be reliably distinguished.

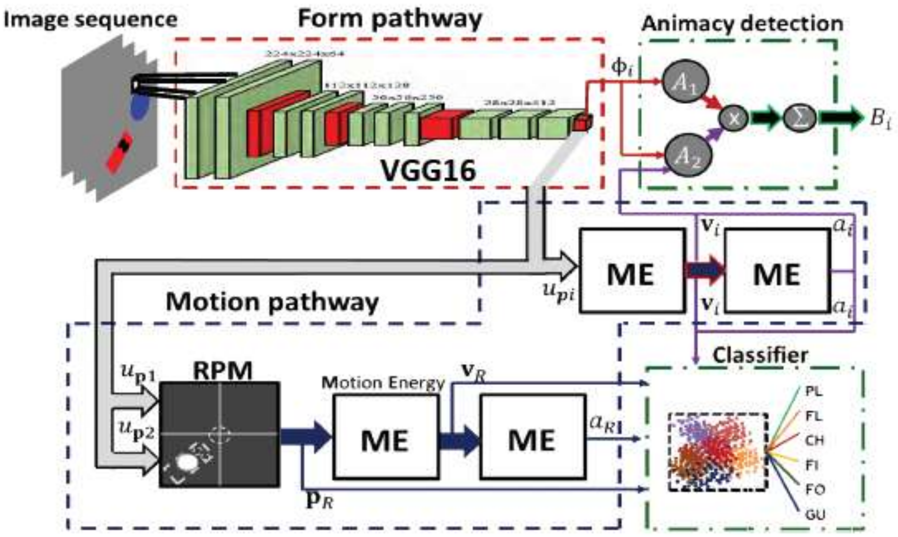

Fig. 3 Neural model architecture extending a standard model of the visual pathway by neural circuits that analyze perceived agency and classify social interactions.

Classifier	Accuracy
Linear SVM	99.0%
Gaussian kernel SVM	96.3%
LDA	94.7%
KNN	94.7%
Nonlinear LDA	94.3%
Neural Network	94.0%

Table 1 Peformance of the neural model using different types of classifiers at the highest hierarchy level.