

Abstract

Specialised face processing in fusiform-face-area relies on horizontal orientations (Goffaux et al. 2016). We developed a neural-network to investigate the roles of different levels of the visual system. We trained a spiking-neural-network with face images (54x54 pixels), using a spike-time-dependent-plasticity (STDP) learning rule whereby synapses receiving spikes before/after the cell fires are strengthened/weakened (Masquelier and Thorpe, 2007). This network type closely matches V1 receptive fields (RF) (Cottureau et al. 2019). The network had a convolutional LGN layer consisting of ON and OFF cells and a convolutional V1 layer consisting of 4 Gabor orientation filters (0/90/45/135 degrees, with ~ 2 spatial frequency cycles-per-RF). Each V1 cell type (0/90/45/135) had synaptic connections to one of LGN cell type (ON/OFF). Thus there were 8 channels in V1. Each cell in the final layer (N=20) had synaptic connections to all V1 cells (thus a total of $2 \times 4 \times 54 \times 54 = 23328$ synapses). After training, we inspected the synaptic weights (learned though STDP) connecting the V1 layer to the final layer. The weights learned for horizontal V1 channels were highest around the eyes, eyebrows and mouth - highly important for face identification, whereas weights for the vertical channels were highest for the sides of the head/ears and nose. Next we measured the local similarity of the weights at each pixel location, separately for horizontal and vertical channels. There was significantly increased similarity around the eyes in the horizontal compared to vertical channel. This may mean that a small and specific configuration of horizontal orientation filters are useful in representing this face region. These results replicate previous research and suggest that specific facial features may drive the reliance on horizontal orientations. Moreover, different RFs converged on a similar configuration of horizontal orientations to represent the eyes - possibly indicating a smaller space of possibilities for representing certain facial features.

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