Connectionist simulations with a dual route model of fear conditioning

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The neurobiological dual route model of fear conditioning, developed by LeDoux (1996), was investigated in four simulations within a connectionist framework using CALM Maps, a competitive learning procedure. The theoretical model posits the existence of two distinct neural pathways to the amygdala in emotional processing, the cortical and the sub-cortical pathway. These pathways have different functions in processing emotional stimuli, due to their difference in length and processing capacity.

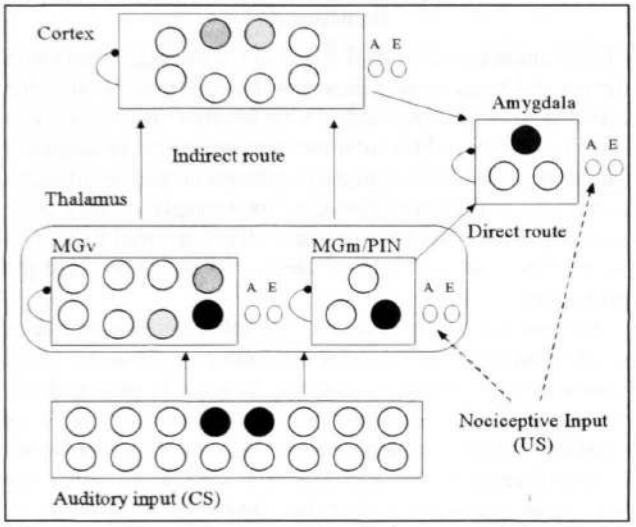

Figure 1: The architecture of the dual route model.

We adapted the model (Figure 1), and then successfully replicated the Armony et al. simulations, consisting of shifts in receptive fields of individual nodes and an overall behavioral change due to conditioning (Figure 2). Contrary to the Armony et al. model, the representations were ordered topologically in all modules, and the unconditioned stimulus (US) was presented to the CALM Arousal-node, which increases the learning rate, instead of feeding it directly to the regular nodes.

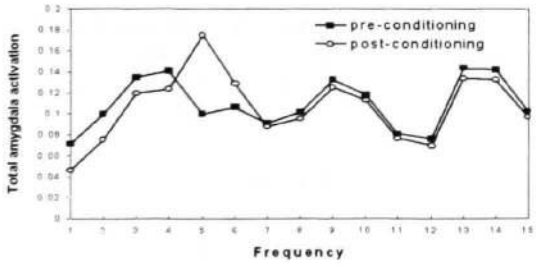

Figure 2: Amygdala activation as a function of frequency.

Additional simulations elaborated on specific aspects of CALM Maps. Extinction could be observed in the model, but only by presenting interfering stimuli along with the conditioned stimulus over a number of presentations (Figure 3). Latent inhibition, the lower susceptibility to conditioning of a familiar stimulus relative to an unfamiliar one, emerged naturally from the arousal system in CALM Maps, which will be activated by presentation of a novel stimulus. Thus, in conditioning a novel stimulus both the novelty of the CS and the noxiousness of the US contribute to an increased learning rate.

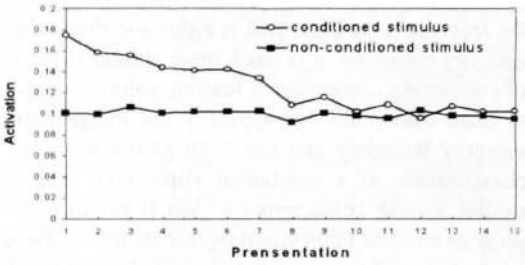

Figure 3: Extinction over time in the amygdala.

The relative contribution of both pathways to the behavior of the model was examined in several lesion experiments. Lesions were both administered before and after conditioning. These showed that the indirect pathway contributed little to the conditioned behavior of the model. One way to obtain larger activations in the cortex may be to incorporate bi-directional connections between thalamus and cortex, so that positive feedback would enhance the strength of representations in the cortex.

Our model showed some promising results, based on treating US-stimuli as generators of arousal. Furthermore our model succeeded in simulating conditioning mechanisms not discussed in the Armony et al. simulations. Further research along the lines of this model, which would extend its implications beyond conditioning, might be simulations of conscious versus non-conscious affective processing such as for instance described by Murphy and Zajonc (1993).

References

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