TIMING OF CLASSICIALLY CONDITIONED PURKINJE CELL PAUSE

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Introduction

The cerebellar cortex has been shown to be critically involved in classical conditioning of the eyelid response (see Fig. 1). Purkinje cells (Pc) and interneurons in the cerebellar cortex receive convergent input from mossy fibres (mf) and climbing fibres (cf), generally assumed to transmit the CS and US signals respectively. Classical Conditioning models predict that PCs involved in control of the eyelid response will learn to pause (since PCs inhibit) in response to the CS. Such a pause will distribute the interpositus nucleus (AIN) and elicit an eyeblink. We have previously demonstrated that the mf transmit the CS-signal to the cerebellum and that a well-timed pause in PCs activity is present in animals conditioned with a periorbital US. Furthermore, paired mf and inferior olive (IO) stimulation has been shown to induce such a pause in the Pcs (poster Neuroscience 2003).

Classical conditioning

Experimental set-up

Methods

Two experiments were performed on decerebrate male feral rats (Fig. 2) during standard decerebration conditioning. In the first experiment, EMG-recordings were made from the m. orbicularis oculi and in the second experiment the activity of a single Pc in the c3 zone of the cerebellar cortex was recorded extracellularly in vivo.

- CS: A 60 Hz, 90 µA electrical stimulus train was applied to the mf in the middle cerebellar peduncle.
- US: Two 10 ms electrical stimulus trains (5 pulses at 500 Hz) were applied to the periorbital area (3 mA) in the EMG-recording experiment, or to the IO (150 µA) in the Pcs recording experiment.

Initial acquisition training was performed with a 300 ms ISI (and CS duration) until reliable conditioned responses (eyelids or Pc pauses) were observed. The ISI and CS duration were then increased to 500 ms. Paired CS-US stimulation with the longer ISI continued for an additional 400 trials.

Early training with 300 ms ISI

Results

Eyeblink EMG-recordings

After acquisition, eyelid CRs were timed in accordance with the shorter (300 ms) ISI. The response latency was approximately 200 ms after CS onset. After the following 400 trials of training with the longer (500 ms) ISI, CRs had adapted to the longer ISI and the latency had increased to ~350 ms.

Purkinje cell recording

The Pc responses to the mossy fibre CS was initially excitatory, i. e. produced increased simple spike activity. However, after 300 trials of paired mf and IO-stimulation, f. Pc had developed a reliable pause response to the CS with an onset latency of ~175 ms. After 400 trials of training with the longer (500 ms) ISI, the Pc pause had adapted to the longer ISI and the onset latency had increased to ~350 ms.

Conclusion

- In animals conditioned with a mossy fibre CS and inferior olive US, Purkinje cells acquire a pause response which is timed to the inter stimulus interval.
- An increase of the inter stimulus interval causes the Purkinje cell pause response latency to increase accordingly after 400 trials of paired CS-US stimulation.
- The observed change in timing of the Purkinje cell pause responses shows a striking similarity to the observed change in timing of eyelid EMG-activity in animals conditioned with a periorbital US.

These observations are in agreement with previous investigations and strongly support the hypothesis that eyelid conditioning causes acquisition of a pause in Pc simple spike activity induced by converging mf and of input. Furthermore, these data suggest a critical role for the cerebellar cortex in the acquisition, expression and the temporal control of conditioned responses.

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References

Note: The references are not included in the natural text as they are not relevant to the main content of the document.