A computational model of adaptive blink modification by the cerebellum

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Adaptive gain modification of the blink reflex, as is produced by applying tonic force to the eyelid, has been proposed as a model system for motor learning (Evinger & Manning 1988). As in the vestibulo-ocular reflex (VOR), learning to compensate for changes in the output system (i.e. plant) depends critically on the cerebellum. A computational model of the VOR suggests that plant compensation can be achieved by an adaptive filter version of the Marr-Albus model of the cerebellum embedded in a recurrent architecture with covariance learning rule (Dean, Porrill & Stone 2002). Here we extend this model to adaptive blink modification.

The model architecture consisted of a non-adaptive brainstem pathway and a parallel adaptive cerebellar pathway, converging on the premotor nuclei of the eyelid plant (Lepora et al 2007, Lepora et al 2009). The brainstem input was the sensory stimulus eliciting the blink, while the cerebellar mossy-fibre input was an efferent copy of the blink motor command. A key difference between VOR and blink adaptation is that the former can use retinal slip as an error signal. Here we investigated continuous tracking error, analogous to retinal slip, as a possible climbing fibre input. This signal consists of signed position error relative to the desired current state (fully open or fully closed).

Model performance was assessed by its ability to compensate for changes in plant gains, as induced experimentally. Initial investigations indicated that the tracking error signal produced stable learning as in the VOR model. In addition, an error signal restricted to only endpoint information about blink completion also produced good plant compensation, at least for certain adaptive-filter basis functions.

The cerebellar role in blink adaptation can therefore be modelled with an adaptive filter architecture as in the VOR, provided appropriate error information is available. This result illustrates the importance of obtaining direct experimental evidence for the error signal, especially as end-point error is very similar to the signal proposed for saccadic adaptation (Soetejdo and Fuchs 2006). It is currently unclear whether the error signals investigated here could be combined in the same microcomplex with the US-driven error signal thought to drive classical conditioning (c.f. SFN poster by Lepora et al. (2007)).

Some of the work in this abstract has been published in (Lepora et al 2010).

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