Eye Movement Artifact Do Not Account for Feedback-Related Potentials in Nonhuman Primates

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In a journal club paper Godlove suggested that eye movement artefact may account for our data on frontal feedback-related potentials (FRP) in monkeys (Vezoli and Procyk 2009). Indeed eye movements can induce phasic signals on EEG recordings, and in most trained behavioural tasks monkeys generate saccades at the termination of trials or at the time of reward delivery. We address the putative confounds listed in Godlove's review and provide clear responses showing that saccades had no effect on FRP.

First, Goldlove misread our article concerning signals in first correct (CO1) and correct repetition (COR) trials. eFRP for CO1 were larger than for COR trials as outlined in the discussion (see also Results and Table S1); consequently the positive peak of difference-wave for INC-COR was larger than for INC-CO1.

Second, feedback stimuli were matched for luminance (green disks 0.71 Cd/m\textsuperscript{2} and red disks 0.68 Cd/m\textsuperscript{2}).

Third, and most importantly, overall saccade latencies occurred around feedback offset i.e. away from the potential of interest (0.52±0.14s and 0.60±0.12s for monkey S and R respectively). Contrary to Godlove's predictions, and rather unexpectedly, saccades after COR feedback had shorter latencies than after INC or CO1 (t-tests: \(p<0.05 \) \(t>3.1\) in all cases, except between INC and CO1 for monkey S, ns), with an overall COR saccade latency of 0.49±0.06s.

Fourth, as can be noted from single trial data, we observed no "smear" of FRP peaks proportional to saccade latencies, but we could observe a negative deflection at saccade onset for some trials (Fig. 1A). EOG based rejection (removing all trials in which a saccade occurred during feedback onset) led to the removal of 17±10\% of trials, which induced no significant changes in difference waves (Fig. 1B).

Finally, there was no latency increase under haloperidol: no effect in one monkey and a shortening of latencies in the other (tests per condition e.g. INC Control vs. Haldol; for monkey S, all test ns, INC: \(p=0.85\) \(t=0.18\), CO1 \(p=0.72\) \(t=0.36\), COR \(p=0.8998\) \(t=-0.126\); for monkey R, no effect on saccade latency after CO1, \(p=0.58\) \(t=-0.55\), but shorter latencies after haldol for INC, \(p=0.003\), and COR, \(p<10^{-4}\) \(t=4.38\)). In any case mean saccade latencies were away from the peaks of interest (>400ms).

We very much appreciate the review by Godlove, which has contributed significantly to the refinement of our original report on performance monitoring signals in non-human primates.

No effect of saccades on FRP data

Figure 1. In A, representative example of single trial ERP data aligned on negative (left) or positive (right) feedbacks and sorted by saccade latencies (small circles: saccade onset). Note the absence of any effect of saccades on the eFRP, although a negative artefactual deflection is observed at saccade onset. In B, grand average waveforms with (upper) and without (lower) saccade rejection. Solid black lines show FRPs aligned on COR feedback and broken black lines show FRPs aligned on INC feedback. Difference wave (INC-COR, in red) is not altered when removing eye movements made after feedback onset (t-tests for amplitude: p=0.42 t=-0.81 df=34 and p=0.62 t=0.50 df=26, and latency: p=0.62 t=-0.49 df=34 and p=0.20 t=1.3 df=26 for monkey S and R respectively). In the lower figure, about 17% of data has been removed from FRP trace.