Nonlinear integration of evidence in a dynamic motor task

Citation for published version:
Fiedler, K & Michael Herrmann, J 2011, 'Nonlinear integration of evidence in a dynamic motor task' BMC Neuroscience, vol 12, 148. DOI: 10.1186/1471-2202-12-S1-P148

Digital Object Identifier (DOI):
10.1186/1471-2202-12-S1-P148

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Publisher's PDF, also known as Version of record

Published In:
BMC Neuroscience

General rights
Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.
Nonlinear integration of evidence in a dynamic motor task

Katja Fiedler1,2*, J Michael Herrmann2,3

From Twentieth Annual Computational Neuroscience Meeting: CNS*2011
Stockholm, Sweden. 23-28 July 2011

Introduction
Reaching movements are governed by estimates of sensory and environmental quantities. If performed under uncertainty they are often based on prior expectations that summarise previous relevant information. We study the temporal evolution of the decision priors in a two-alternative forced-choice movement task.

Methods
We acquired data from four right-handed and four left-handed participants who performed an obstacle avoidance task using a manipulandum (Phantom 3.0). In each trial, downward movements were initially directed towards an intermediate target. When arriving at the via-point the location of the final target was revealed which indicated whether the obstacle was to be circumvented on its right or left side. The task was spatially symmetric and the laterality of the final target was overall balanced, the first tens of trial, however, were deliberately weakly biased towards one side. The validity of a trial required reaching the final target within a short time interval by passing the obstacle on the correct side. When departing from the intermediate target, participants often moved briefly towards the wrong side before reverting this preliminary decision and proceeding toward the final target along the correct side. The interim movements were extracted from four blocks of 250 valid trials each for both dominant and non-dominant hand for each participant. The data were statistically analysed using linear models for a local description of interim movements and a non-linear model for the description of the dynamics of the decision priors.

Results
Analysing directional decisions in dependence on a bias in target presentation, we find that all participants have a strong tendency to adopt the initial bias from the presented distribution. This tendency is strengthened during breaks between sessions. Only when a large number of trials that provide evidence to the contrary a small but significant adjustment of the decision strategy is observable. The results are reproduced independently of handedness. After a large number of strongly biased interim movements the subjects tend to realise the sub-optimality of their decision strategy and return briefly to a less biased behaviour which is, however, typically unstable. These phenomena are shown to be independent of handedness.

Linear modelling (SARMA) revealed that the movement decision becomes soon nearly independent of the task, but is predictable by earlier movement decisions although information from earlier trials is statistically irrelevant. This effect can be captured for all naïve participants by a non-linear model of symmetry breaking in the decision task. Instead a nonlinear model of decision making is required which involves different time scales for formation of estimates and movement generation.

Conclusion
Instead of constructing an internal representation of the statistical distribution of the task and their sensory uncertainty, the participants were forming a reflexive prior of their previous actions, while the performance of the task was achieved by reactive control, cf. [1]. Although information from earlier trials is statistically irrelevant, its effect could not be ignored and introduced a strongly biased perception of the task. We conclude that our results do not question the Bayesian paradigm in sensorimotor control, but may introduce an

* Correspondence: katja@nld.ds.mpg.de
1 MPI for Dynamics and Self-Organization, Bunsenstr. 10, Goettingen, D-37073, Germany
2 Full list of author information is available at the end of the article

© 2011 Fiedler and Michael Herrmann; licensee BioMed Central Ltd. This is an open access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/2.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
inaccurate and potentially suboptimal representation of the environment.

Acknowledgments
This work was partially supported by DIP F1.2 and BMBF, grants 01GQ0432, 01GQ1005A, and 01GQ1005B. We thank Sascha Wolf, Florentin Woergoetter, Tamar Flash and Sarah Solla for stimulating discussions.

Author details
1MPI for Dynamics and Self-Organization, Bunsenstr. 10, Goettingen, D-37073, Germany. 2BFNT Goettingen, Bunsenstr. 10, Goettingen, D-37073, Germany. 3School of Informatics, IPAB & ILSI, University of Edinburgh, 10 Crichton St, EH8 9AB, Scotland, UK.

Published: 18 July 2011

Reference
1. Koerding KP, Wolpert DM. Bayesian integration in sensorimotor learning. Nature 2004, 427:244-247.

doi:10.1186/1471-2202-12-S1-P148
Cite this article as: Fiedler and Michael Herrmann. Nonlinear integration of evidence in a dynamic motor task. BMC Neuroscience 2011 12(Suppl 1): P148.