

POSTER PRESENTATION

Open Access

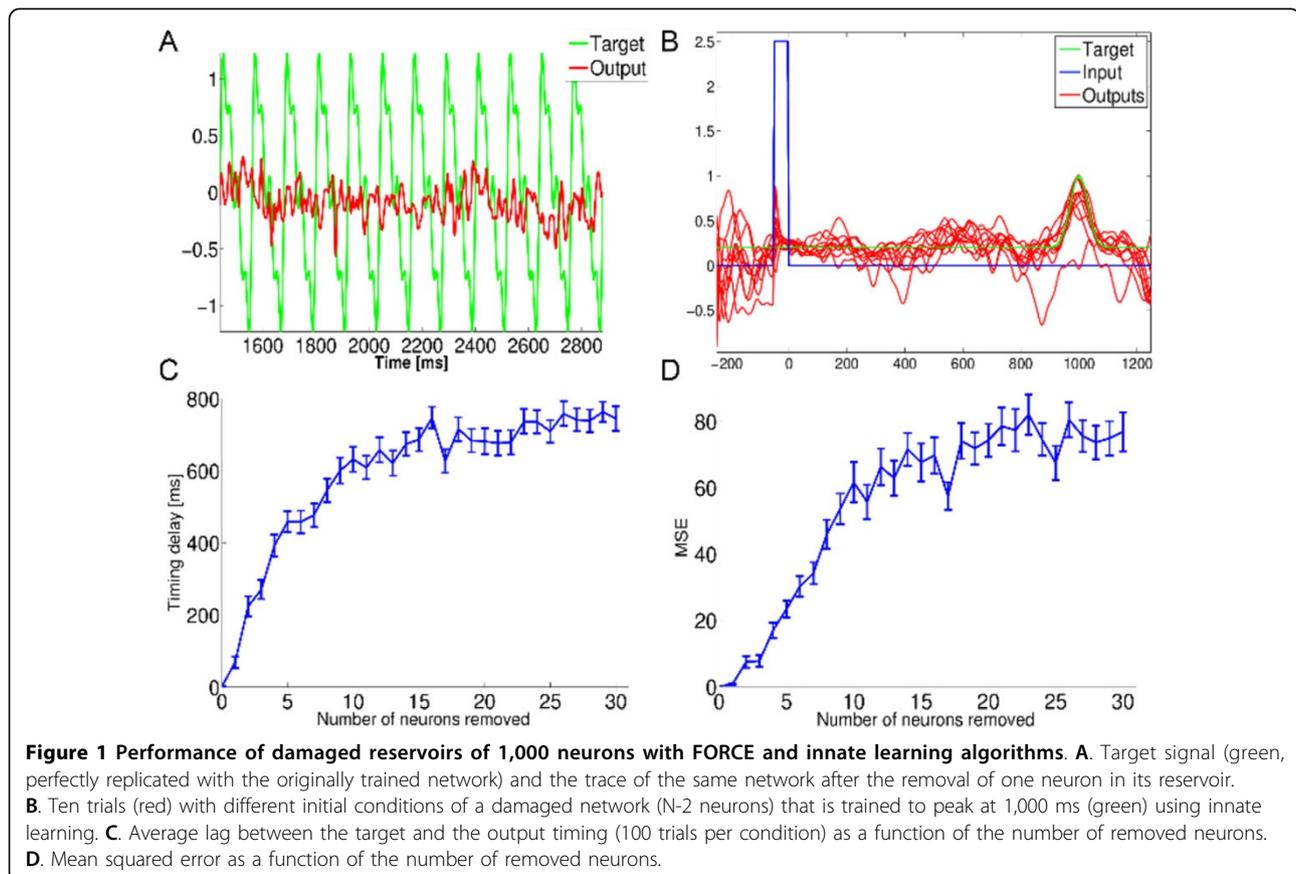
Extreme sensitivity of reservoir computing to small network disruptions

Philippe Vincent-Lamarre^{1*}, Guillaume Lajoie^{2,3}, Jean-Philippe Thivierge¹

From 24th Annual Computational Neuroscience Meeting: CNS*2015
Prague, Czech Republic. 18-23 July 2015

Recent computational models based on reservoir computing (RC) are gaining attention as plausible theories of cortical information processing. In these models, the activity of a recurrently connected population of neurons

is sent to one or many read-out units through a linear transformation. These models can operate in a chaotic regime which has been proposed as a possible mechanism underlying sustained irregular activity observed in



* Correspondence: pvinc058@uottawa.ca

¹School of Psychology and Center for Neural Dynamics, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada

Full list of author information is available at the end of the article

cortical areas [1,2]. Furthermore, models based on RC replicate the neural dynamics involved in decision making [3], interval timing [2], and motor control [1]. However, one biological constraint that has been overlooked in these models is their resistance to small connectivity perturbations such as failures in synaptic transmission, a phenomenon that occurs frequently in healthy circuits without causing any drastic functional changes. Here, we show that different implementations of RC display very little resistance to small synaptic disruptions and discuss the implications of such fragility for RC mechanisms that may be present in neural coding. With the FORCE [1] procedure, networks lost their ability to replicate a jagged sinusoidal signal after a single neuron was removed from the reservoir (Figure 1A). Networks with innate training [2] showed a similar effect on a timing task (Figure 1B). The lag in the timing and the noise in the output both increased monotonically as further neurons were removed (Figure 1C,D); networks reached random performance after ~1.5% of neurons were eliminated. After the suppression of a single neuron, the spectrum of the weight matrix was greatly disturbed and repeated trials displayed unreliable trajectories, as assessed with principal components analysis. When individual synapses were removed instead of neurons, networks reached random performance after ~0.5% of synapses from the reservoir were eliminated. While living neuronal circuits can withstand small synaptic disruptions without compromising task performance, our results suggest that such disruptions have a catastrophic impact on the behaviour of RC models. Retraining the read-out unit seems to be futile as it results as a completely new solution post retraining instead of a finer restructuration. These results cast doubt on the validity of a large class of models that claim to capture the neuronal mechanisms of cognitive and behavioral tasks.

Acknowledgements

This research was funded by grants to J.P.T. from NSERC Discovery and CIHR operating funds.

Authors' details

¹School of Psychology and Center for Neural Dynamics, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada. ²UW Institute for Neuroengineering, University of Washington, Seattle, WA, US. ³Max Planck Institute (DS) and Bernstein Center for Computational Neuroscience, Göttingen, Germany.

Published: 18 December 2015

References

1. Sussillo D, Abbott LF: **Generating Coherent Patterns of Activity from Chaotic Neural Networks.** *Neuron* 2009, **63**:544-557.
2. Laje R, Buonomano DV: **Robust timing and motor patterns by taming chaos in recurrent neural networks.** *Nat Neurosci* 2013, **16**:925-933.
3. Barak O, Sussillo D, Romo R, Tsodyks M, Abbott LF: **From fixed points to chaos: Three models of delayed discrimination.** *Progress in Neurobiology* 2013, **103**:214-222.

doi:10.1186/1471-2202-16-S1-P256

Cite this article as: Vincent-Lamarre *et al.*: Extreme sensitivity of reservoir computing to small network disruptions. *BMC Neuroscience* 2015 **16**(Suppl 1):P256.

**Submit your next manuscript to BioMed Central
and take full advantage of:**

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit

