



How to prepare a high quality research article

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Writing expert texts

- Do we write for a deadline?
- Do we write for the reader?
- Do we seek to get published in a scientific journal?

Main Sources

- The advice of an editor-in-chief (Kwan Choi, 2002)
- AAAS Science Magazine, 2024
- Springer Nature (various journals), 2025
- ...
- Personal experience of GM (the harsh reality)

Three Parties

Scientific publishing hinges upon the trust among

- Authors
- Editors
- Reviewers

A scientific paper is

- A written report describing original research
- Its format has been defined by centuries of developing tradition
- Influenced by editorial practice, printing and publishing services
- Scientific ethics

A result of this process is that virtually every scientific paper has

- Title
- Abstract
- Introduction
- Materials and Methods
- Results
- Discussion
- References

Title

- A title should be the fewest possible words that accurately describe the content of the paper.
- Omit all waste words such as "A study of ...", "Investigations of ...", "Observations on ...", etc.
- An improperly titled paper may never reach the audience for which it was intended, so be specific.

To get more citations, use tripartite phrases in academic paper titles!

- Bornmann, Lutz and Wohlrabe, Klaus, Pattern, Perception, and Performance: Tripartite Phrases in Academic Paper Titles (January 31, 2025). CESifo Working Paper No. 11671, <https://ssrn.com/abstract=5134534> or <http://dx.doi.org/10.2139/ssrn.5134534>

Examples

Table 1: Title examples containing tripartite phrases

Economics

Envy, inequality and fertility

Informed trade, uninformed trade and stock price delay

Housing, adjustment costs, and macro dynamics

Trade, development, and poverty-induced comparative advantage

Market concentration, collusion and social welfare in Mexico: A methodological update

(Bornmann & Wohlrabe, 2025)

Abstract

- A well-prepared abstract enables the reader to identify the basic content of a document quickly and accurately,
- To determine its relevance to their interests,
- To decide whether to read the document in its entirety.

- Does not include details of the methods used unless the study is methodological, i.e. primarily concerned with methods.

- Do not repeat information contained in the title. The abstract, together with the title, must be self-contained as it is published separately from the paper in abstracting services.

An example: *Nature's* abstract
(also called 'First paragraph' or 'Summary
paragraph')

nature

How to construct a *Nature* summary paragraph

Annotated example taken from *Nature* 435, 114–118 (5 May 2005).

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

One sentence clearly stating the **general problem** being addressed by this particular study.

One sentence summarizing the main result (with the words “**here we show**” or their equivalent).

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline, may be included in the first paragraph if the editor considers that the accessibility of the paper is significantly enhanced by their inclusion. Under these circumstances, the length of the paragraph can be up to 300 words. (This example is 190 words without the final section, and 250 words with it).

During cell division, mitotic spindles are assembled by microtubule-based motor proteins^{1,2}. The bipolar organization of spindles is essential for proper segregation of chromosomes, and requires plus-end-directed homotetrameric motor proteins of the widely conserved kinesin-5 (BimC) family³. Hypotheses for bipolar spindle formation include the ‘push–pull mitotic muscle’ model, in which kinesin-5 and opposing motor proteins act between overlapping microtubules^{2,4,5}. However, the precise roles of kinesin-5 during this process are unknown. Here we show that the vertebrate kinesin-5 Eg5 drives the sliding of microtubules depending on their relative orientation. We found in controlled *in vitro* assays that Eg5 has the remarkable capability of simultaneously moving at $\sim 20 \text{ nm s}^{-1}$ towards the plus-ends of each of the two microtubules it crosslinks. For anti-parallel microtubules, this results in relative sliding at $\sim 40 \text{ nm s}^{-1}$, comparable to spindle pole separation rates *in vivo*⁶. Furthermore, we found that Eg5 can tether microtubule plus-ends, suggesting an additional microtubule-binding mode for Eg5. Our results demonstrate how members of the kinesin-5 family are likely to function in mitosis, pushing apart interpolar microtubules as well as recruiting microtubules into bundles that are subsequently polarized by relative sliding. We anticipate our assay to be a starting point for more sophisticated *in vitro* models of mitotic spindles. For example, the individual and combined action of multiple mitotic motors could be tested, including minus-end-directed motors opposing Eg5 motility. Furthermore, Eg5 inhibition is a major target of anti-cancer drug development, and a well-defined and quantitative assay for motor function will be relevant for such developments.

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Letter

Intrinsic honesty and the prevalence of rule violations across societies

Simon Gächter  & Jonathan F. Schulz 

Nature **531**, 496–499 (24 March 2016)

doi:10.1038/nature17160

[Download Citation](#)

[Coevolution](#) [Human behaviour](#)

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- Deception is common in nature and humans are no exception¹. Modern societies have created institutions to control cheating, but many situations remain where only intrinsic honesty keeps people from cheating and violating rules. Psychological², sociological³ and economic theories⁴ suggest causal pathways to explain how the prevalence of rule violations in people's social environment, such as corruption, tax evasion or political fraud, can compromise individual intrinsic honesty. Here we present cross-societal experiments from 23 countries around the world that demonstrate a robust link between the prevalence of rule violations and intrinsic honesty. We developed an index of the 'prevalence of rule violations' (PRV) based on country-level data from the year 2003 of corruption, tax evasion and fraudulent politics. We measured intrinsic honesty in an anonymous die-rolling experiment⁵. We conducted the experiments with 2,568 young participants (students) who, due to their young age in 2003, could not have influenced PRV in 2003. We find individual intrinsic honesty is stronger in the subject pools of low PRV countries than those of high PRV countries. The details of lying patterns support psychological theories of honesty^{6,7}. The results are consistent with theories of the cultural co-evolution of institutions and values⁸, and show that weak institutions and cultural legacies^{9,10,11} that generate rule violations not only have direct adverse economic consequences, but might also impair individual intrinsic honesty that is crucial for the smooth functioning of society.

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Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

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One sentence clearly stating the **general problem** being addressed by this particular study.

- Psychological², sociological³ and economic theories⁴ suggest causal pathways to explain how the prevalence of rule violations in people's social environment, such as corruption, tax evasion or political fraud, can compromise individual intrinsic honesty.

One sentence summarizing the main result (with the words “**here we show**” or their equivalent).

- Here we present cross-societal experiments from 23 countries around the world that demonstrate a robust link between the prevalence of rule violations and intrinsic honesty. We developed an index of the ‘prevalence of rule violations’ (PRV) based on country-level data from the year 2003 of corruption, tax evasion and fraudulent politics.

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

- We measured intrinsic honesty in an anonymous die-rolling experiment⁵. We conducted the experiments with 2,568 young participants (students) who, due to their young age in 2003, could not have influenced PRV in 2003. We find individual intrinsic honesty is stronger in the subject pools of low PRV countries than those of high PRV countries.

One or two sentences to put the results into a more **general context**.

- The details of lying patterns support psychological theories of honesty^{[6](#),[7](#)}. The results are consistent with theories of the cultural co-evolution of institutions and values^{[8](#)}, and show that weak institutions and cultural legacies^{[9](#),[10](#),[11](#)} that generate rule violations not only have direct adverse economic consequences, but might also impair individual intrinsic honesty that is crucial for the smooth functioning of society.

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Beginning

- The manuscript should start with a brief introduction describing the paper's significance.
- The introduction should ensure that the significance of the experimental findings is clear.
- Provide sufficient background information to make the article intelligible to readers in other disciplines.

Write on an interesting subject

- There must be an interesting story, a story that nonexperts—who would skip all the equations—would find intriguing.
- Controversies and debates stimulate reader interest.
- Before writing, answer the question: What new ideas or results does this paper offer?

Write clearly

- The main assumptions and results should be explained clearly. If there are many assumptions, present them together in one place. Do not bury them in long paragraphs.

Get the reader's attention early

- If an apple does not taste good at the first bite, one simply throws it away without giving any thought on the nutritional value hidden in the apple.
- Likewise, most readers make up their mind at the first bite, i.e., within minutes of reading a paper.

Discuss real-world examples

- Pass the relevance test by providing citations, statistics, or anecdotes of real-world examples.
- Without this sound footing in the real world, your paper may give the impression to readers that it provides a profound solution to nonexistent problems.

Imitate skilful writers

- Observe how other successful writers introduce their topic, cite literature, and get on with their task.
- Imitate their words and phrases, and modify them to suit your purpose.
- It is easier to imitate what someone else has written than to create a totally new paragraph.

Do not plagiarize

- If you are quoting statements made by another writer, use identifying quotation marks.
- Do not copy but summarize the contributions of other writers in your own words to the extent that they are related to the subject of your paper.
- Mention the cited author with year of publication in the text and give the exact source in the reference section.

When it is and isn't OK to recycle text in scientific papers

(Nature Human Behaviour, 25 March 2024)

- In scientific writing, one common form of text recycling is the reuse of text from methods sections.
- In these cases, *NHB* consider reuse of text to be appropriate and desirable to ensure clarity and consistency.

Treat others generously

- Emphasize the importance of the paper being written, but not at the expense of others.
- Don't hit people. Do not hurt their feelings.
- When mentioning the works of other persons, avoid using negative terms.

Find quotations from well-known authors

- This strategy increases the credibility of the paper.
- For instance, if John Maynard Keynes or Kenneth Arrow said something about the topic, it is difficult to argue that your paper is uninteresting.
- Do not quote dead people too often.
- Do not quote yourself (too much). This implies narcissism or lack of exposure to the thinking of others.

Start writing before the paper is finished in your head

- Writing a paper is like stringing pearls to make a necklace. There is an optimum order for these pearls to form a paper, and some pearls are better left out.
- “Killing my darlings” – a great advice, sometimes difficult to follow.

Do not read too much

- Do not read too much before you begin to write. It can interfere with your own thinking and writing.
- It is impossible to read every paper ever written on a subject.
- If you read a dozen papers on a topic, you should have enough material to write a paper. Now add your own ideas to this base of knowledge. Only then add another dozen.

Strike a balance between theory and applications

- A theoretical paper should say something about policies, applications, or empirical work.
- An empirical paper should say something about the theory that led to the empirical work.

Divide long paragraphs

- If there are two or more ideas in a single paragraph, split them up.
- Break up long paragraphs even if they contain a single idea.
- Readers tend to skip long paragraphs.

Divide long paragraphs II

- The eyes of readers are subconsciously looking for open space. This is why important equations should be displayed, rather than buried in the text.
- No paragraph should be longer than half a page.
- As a general rule, a paragraph should have more than two sentences.

Use tables to summarize results or to compare with the literature

- Tables provide another way to catch the attention.
- Avoid too many numbers in one table.
- Do not present more than three tables, except in empirically oriented papers.

Figures

- A (good) figure is worth a thousand words.
- Do not use too many curves, lines, or labels.
- Ten years after publication, readers may not remember anything about a paper, not equations nor derivations. But they may recall a Figure.

The Paper's Conclusion

- Compare your results to those in the literature.
- If the literature does not have comparable results, discuss how your paper is related to the literature.
- Do not repeat parts of the introduction.

Discuss policy implications

- Explain how the theory applies to real world examples.
- Example: In practice, A is used, but you recommend B, etc.
- Present the bottom line. Mention the implications for policy makers, practitioners, or other researchers.

Some examples from experience

- ... both good and bad
- ... and some painful but instructing



Neural networks letter

Emotional balances in experimental consumer choices

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ABSTRACT

This paper presents an experiment, which builds a bridge over the gap between neuroscience and the analysis of economic behaviour. We apply the mathematical theory of Pavlovian conditioning, known as Recurrent Associative Gated Dipole (READ), to analyse consumer choices in a computer-based experiment. Supplier reputations, consumer satisfaction, and customer reactions are operationally defined and, together with prices, related to READ's neural dynamics. We recorded our participants' decisions with their timing, and then mapped those decisions on a sequence of events generated by the READ model. To achieve this, all constants in the differential equations were determined using simulated annealing with data from 129 people. READ predicted correctly 96% of all consumer choices in a calibration sample ($n = 1290$), and 87% in a test sample ($n = 903$), thus outperforming logit models. The rank correlations between self-assessed and dipole-generated consumer satisfactions were 89% in the calibration sample and 78% in the test sample, surpassing by a wide margin the best linear regression model.

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1. Introduction

John Watson, founder of behaviourism, is quoted to have said in 1922, "The consumer is to the manufacturer, the department stores and the advertising agencies, what the green frog is to the physiologist" (DiClemente & Hantula, 2003). Many decades later, we cannot but agree with this provocative insight, although we know a lot more about consumer behaviour, its conditioning, and economic psychology in general. Today fMRI methods help us discover how brain systems interact when we think about economic decisions (see for example Camerer, Loewenstein, and Prelec (2005)). Yet, these studies still try to locate regions in the cortex involved in forming emotions, judgments, and decision making (cf. Winkielman, Knutson, Paulus, and Trujillo (2007)). It might be advantageous to complement such an observational approach, or even step aside from it for a while, by using more extensively the available theoretical models.

In this paper, we present experimental evidence that the mathematical theory of Pavlovian conditioning, known as Recurrent Associative Gated Dipole (READ) (Grossberg & Schmajuk, 1987) is able to capture essential features of consumer behaviour. A computer based experiment showed how a supplier of a fictitious

service provoked satisfaction and disappointment, and gradually built its own reputation in the minds of participants as consumers. Accommodated by READ, these factors turned out to be strong predictors of customers' decisions to retain or abandon their current supplier. Our work borrows ideas from affective balance theory (Grossberg & Gutowski, 1987) and the Leven and Levine (1996) neural model of a consumer.

2. Experiment

This experiment investigates the links between (1) monetary outcome and momentary affect, (2) previous emotional experience and supplier reputation, and (3) provoked emotions and consumer decisions to retain or abandon the current supplier. It was conducted in May 2007 and involved 129 students of economics from Sofia University. Its content bears resemblance to the Bulgarian market of mobile phone services where two leading providers offered indistinguishable quality and prices at the time of the study. However, similarities with other markets in other countries would have been just as useful.

In each of 17 rounds the participant sees on a computer screen an advertised price (P_a) offered by the current supplier, which serves as orientation about what final price (P_f) might be expected (Fig. 1). No payments with real money are made. Prices P_a were adjusted to fluctuate slightly around an average monthly bill obtained in a survey among another 40 students. Thus, P_a varied within 40 ± 5 Bulgarian leva, and 1 lev is 0.5 euros.

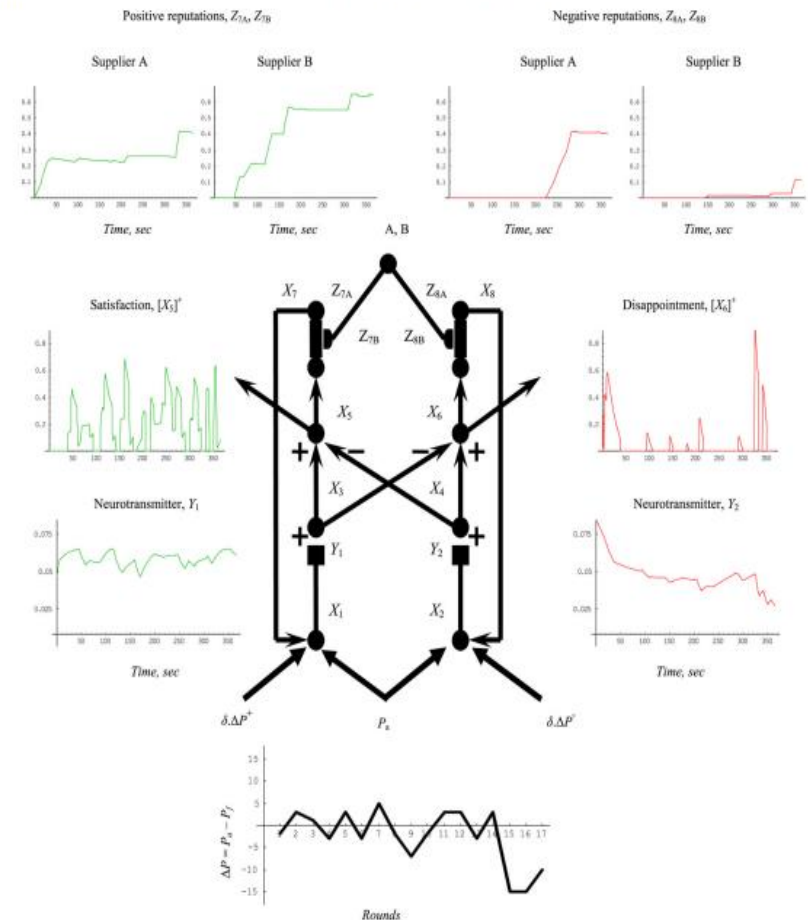


Fig. 3. Relating a participant's data to the READ model. Market is 'saturated'. All plots show variables computed with that person's best set of constants obtained with simulated annealing. Note the Y_2 neurotransmitter release and increased disappointment in the last rounds due to larger unfavourable price differences ΔP . In addition, because the participant switched from Supplier A to B at the end of the first round, A's positive reputation did not change much for a while, while B's increased over the next couple of rounds.

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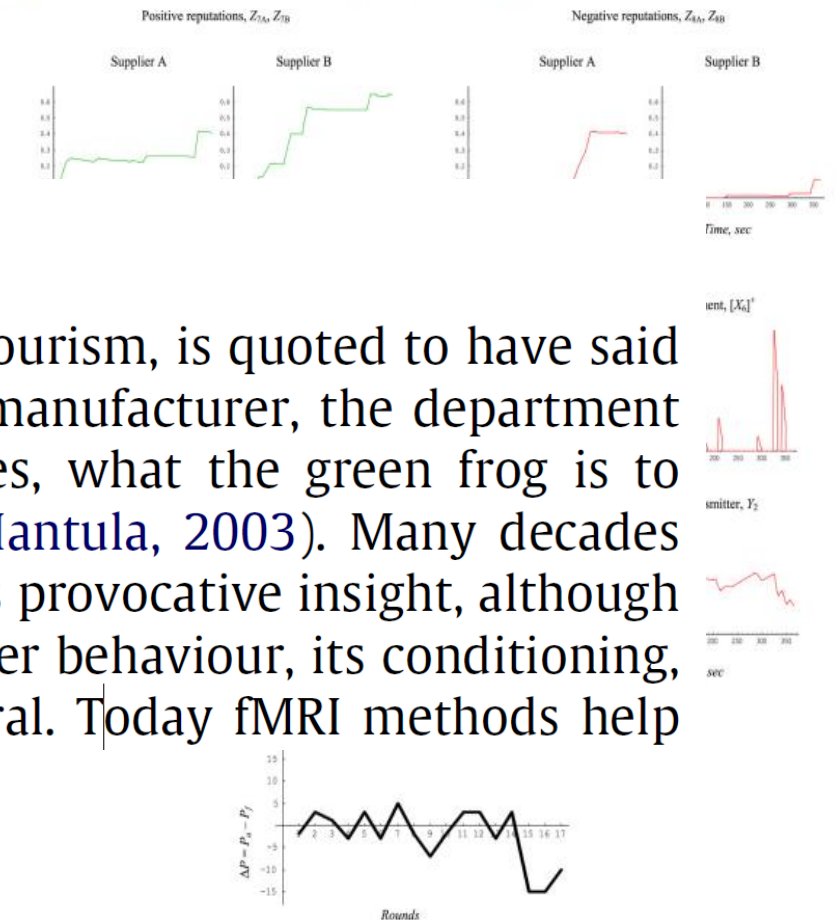


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Person-by-person prediction of intuitive economic choice

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Experimental economics
Gated dipole
Intuitive thinking
Differential equations

ABSTRACT

Decision making is an interdisciplinary field, which is explored with methods spanning from economic experiments to brain scanning. Its dominant paradigms such as utility theory, prospect theory, and the modern dual-process theories all resort to formal algebraic models or non-mathematical postulates, and remain purely phenomenological. An approach introduced by Grossberg deployed differential equations describing neural networks and bridged the gap between decision science and the psychology of cognitive-emotional interactions. However, the limits within which neural models can explain data from real people's actions are virtually untested and remain unknown. Here we show that a model built around a recurrent gated dipole can successfully forecast individual economic choices in a complex laboratory experiment. Unlike classical statistical and econometric techniques or machine learning algorithms, our method calibrates the equations for each individual separately, and carries out prediction person-by-person. It predicted very well the behaviour of 15%–20% of the participants in the experiment – half of them extremely well – and was overall useful for two thirds of all 211 subjects. The model succeeded with people who were guided by gut feelings and failed with those who had sophisticated strategies. One hypothesis is that this neural network is the biological substrate of the cognitive system for primitive-intuitive thinking, and so we believe that we have a model of how people choose economic options by a simple form of intuition. We anticipate our study to be useful for further studies of human intuitive thinking as well as for analyses of economic systems populated by heterogeneous agents.

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1. Introduction

General Charles de Gaulle of France once remarked that it was difficult to govern a nation that had 246 different kinds of cheese. Besides the obvious message about developed countries being sophisticated, these words hint that economic choice is not only important but also somewhat frustrating. Economists have studied its more traditional aspects extensively and have come to the understanding that the axioms used in economic and political theory need revision (Sen, 1997). To better explain and predict, they ought to account for the subtle rationality of seemingly irrational decisions as in Amartya Sen's famous example of somebody taking a fruit from a basket with two fruits, but refusing to do so when only one is left. Behavioural economics has addressed the general issue by relaxing its axioms as well as by equipping them with more empirical knowledge about the human being's cognitive characteristics.

In the meantime, psychology has gone a long way in understanding human decision processes. Kahneman and Tversky's research programme enriched economic analysis with findings about the heuristic and emotional aspects of decision making (Kahneman, 2003, 2011; Tversky & Kahneman, 1971, 1981). In our time, it has been established that a decision is reached in the complex interaction of two cognitive systems. Different theories have labelled them in different ways, but in general it is believed that there is one system for "intuitive", "experiential", or "impulsive" reasoning, also called "System I", and another for "logical", "rational", or "reflective" reasoning, also called "System II" (Epstein, 1994, 2003; Kahneman & Frederick, 2002; Schneider & Shiffrin, 1977; Stanovich & West, 2000; Strack & Deutsch, 2004). Recent reviews on the subject can be found in (Alós-Ferrer & Strack, 2014; Brocas & Carrillo, 2014; Dayan, 2009), while some of the recent modelling advances constitute (Andersen, Harrison, Lau, & Rutström, 2014; Fudenberg & Levine, 2006; Fudenberg, Levine, & Maniadis, 2014; Mukherjee, 2010). In this view, the intuitive system is automatic, effortless, emotion-driven, governed by habit, but difficult to change, while the logical system is effortful, controlled and slow, but flexible and able to adopt complex decision rules. Easy tasks are dealt with

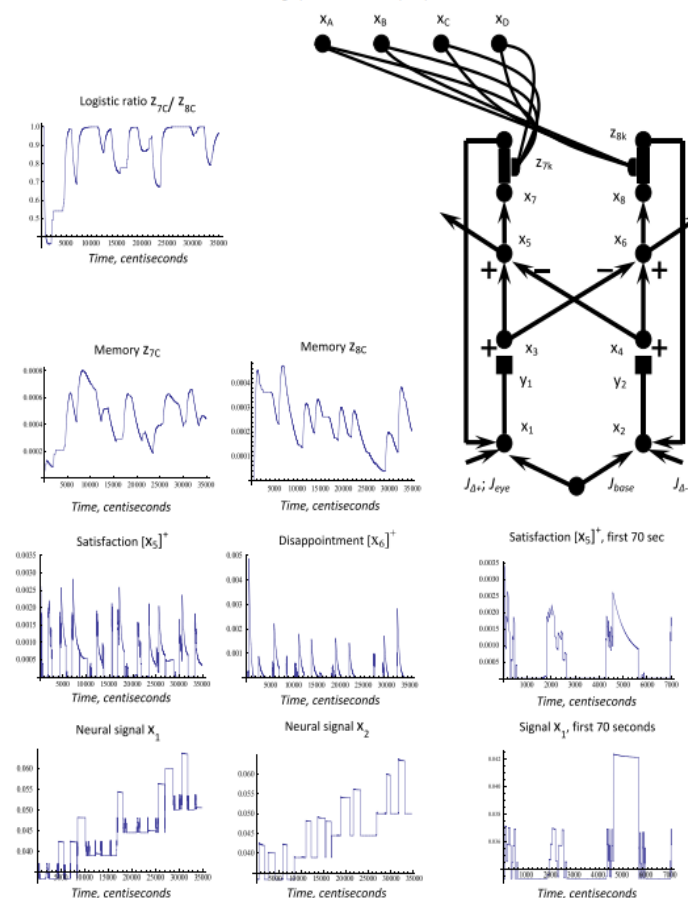


Fig. 3. Dynamics of the neural circuit. **Bottom left and middle plots:** Signals x_1 and x_2 are the responses to the incoming stream of offers, deliveries, and to the participant's eyeballing before choosing. In the example, the person kept choosing Supplier C in the first three rounds and received extra omnium bonum in the third, which is reflected in the two "first 70 seconds" plots (third column, below the neural circuit). There, x_1 produced "ripples" at the onset of each round and then jumped around the 4500th centisecond (45th s) due to the surplus delivered. Around the 2000th centisecond, the corresponding $[x_5]^+$ signal shows that eyeballing four positive options can cause satisfaction, almost as intense as that of the actual lavish treatment. **Upper-left plots:** The memory for positive emotions z_{7C} initially rose negligibly due to eyeballing, and then increased around the 50th second after the generous delivery in the third round. In contrast, the memory for negative emotion z_{8C} rose steeply in the first round and remained high in the next due to disappointingly unfulfilled promises. The supplier's dynamic reputation was defined by the logistic ratio z_{7C}/z_{8C} reflecting the two memories' joint action.

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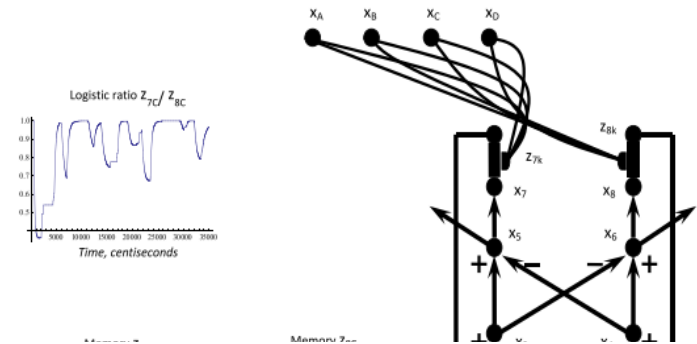
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Virtual social networking increases the individual's economic predictability

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Emotional economic choice
Neural model

ABSTRACT

Forecasting economic choice is hard because today we still do not know enough about human motivation. A fundamental problem is the lack of knowledge about how the neural networks in the brain give rise to thinking and decision making. One way to address the issue has been to develop simplified economic experiments, in which participants need skills of little complexity and their minds employ cognitive mechanisms, already well understood by mathematical psychology and neuroscience. Here we take a neural model for rudimentary emotion generation and memorizing and use it as a guiding theory to understand decision making in an experimental oligopoly market. For the first time in that line of research, participants are put in a lab virtual social network serving to exchange opinions about deals with companies. On average, choices become significantly more predictable when people participate in the network, in contrast to working alone with expert information. Calibrating the model for each person, we find that some people are predicted with startling precision.

1. Introduction

Trying to predict people's actions is hard because not enough is known about the decision making mechanisms of the mind. Cognitive psychology has reached a consensus that the brain does not compute value or utility but conducts ad hoc and direct comparisons between the available options in the specific situation, circumstances, framing, and context (Rieskamp et al., 2006; Vlaev et al., 2011). Any choice forecasting effort, therefore, should humbly accept the prospect to accomplish very little. One approach could be statistical – gather data and use it to anticipate human behavior in the long run. In our time, machine learning with big data has done exactly that, with respectable success. Its main problem though, is that its key component – the artificial neural network – is a black box, not capable of discovering cognitive mechanisms and causal relationships. This lack of strictly scientific knowledge makes the method less effective with unknown data and new situations, posing an upper bound to its achievements.

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work in some economic, consumer, and utility-based choices in general (Levin & Levine, 1996; Levine, 2006; Levine, 2012; Grossberg, 2018).

A parallel line of research conducted experiments with monkeys to identify brain areas and single neurons, believed to encode the usefulness of goods (Padoa-Schioppa & Assad, 2006; Padoa-Schioppa & Assad, 2008; Grabenhorst et al., 2012). These efforts, alongside the entire field of neuroeconomics, have successfully related economic concepts with brain regions in which they are processed. Yet never a serious attempt was made at forecasting economic decisions, obviously due to the huge theoretical gap between neural circuits and actual behavior (Carandini, 2012; Kriegeskorte & Douglas, 2018; Marr, 1982; Palmieri et al., 2017; Turner et al., 2017). Several ways to connect neural with behavioral data have been developed (Zhang et al., 2017; Forstmann et al., 2016; Hein et al., 2016; Schulte-Mecklenbeck et al., 2017; Wang, 2008; Klein et al., 2017; Meder et al., 2017) but no method for their integration has prevailed.

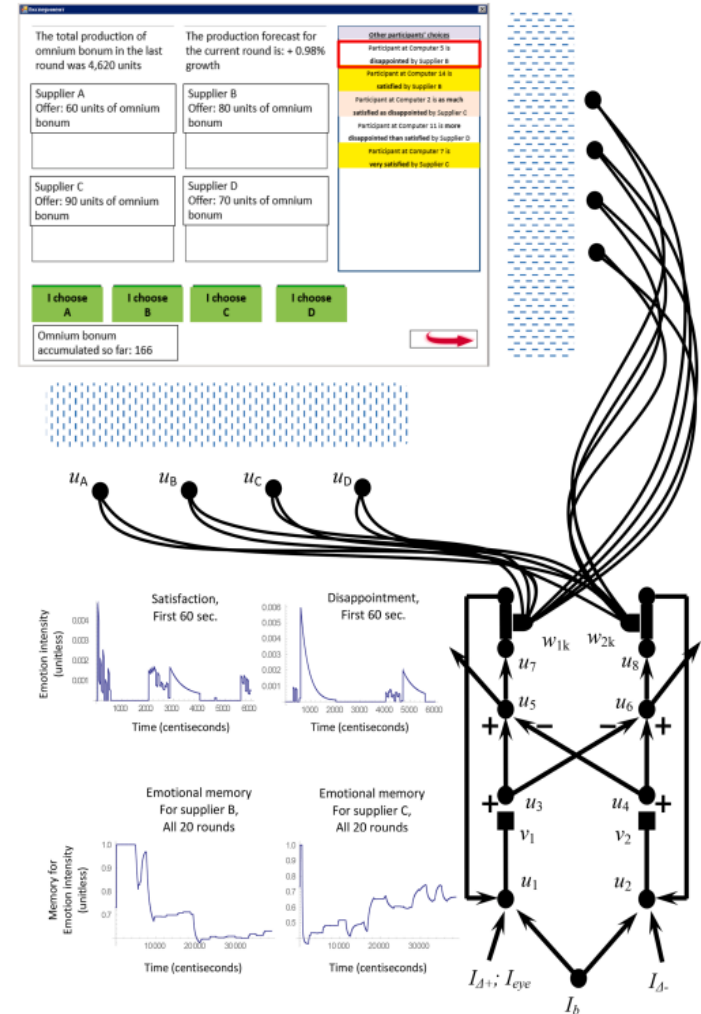
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(caption on next page)



Virtual social networking increases the individual's economic predictability

George Mengov^{a,*}, Nikolay Georgiev^a, Irina Zinovieva^b, Anton Gerunov^a^a Faculty of Economics and Business Administration, Sofia University St. Kliment Ohridski, 125 Tsarigradsko Chaussee Blvd., Bl. 3, Sofia 1113, Bulgaria^b Department of Psychology, Sofia University St. Kliment Ohridski, 15 Tsar Osvoboditel Blvd., Sofia 1504, Bulgaria

ARTICLE INFO

Keywords:
Decision making
Virtual social network
Emotional economic choice
Neural model

ABSTRACT

Forecasting economic choice is hard because today we still do not know enough about human motivation. A fundamental problem is the lack of knowledge about how the neural networks in the brain give rise to thinking and decision making. One way to address the issue has been to develop simplified economic experiments, in

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The total production of omnium bonum in the last round was 4,620 units

The production forecast for the current round is: + 0.98% growth

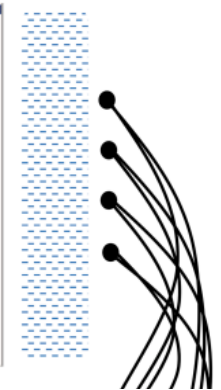
Supplier A Offer: 60 units of omnium bonum	Supplier B Offer: 80 units of omnium bonum
Supplier C Offer: 90 units of omnium bonum	Supplier D Offer: 70 units of omnium bonum

I choose A I choose B I choose C I choose D

Omnium bonum accumulated so far: 166

Other participants' choices

- Participant at Computer 5 is disappointed by Supplier B
- Participant at Computer 14 is satisfied by Supplier B
- Participant at Computer 2 is as much satisfied as disappointed by Supplier C
- Participant at Computer 13 is more disappointed than satisfied by Supplier D
- Participant at Computer 7 is very satisfied by Supplier C



Time (centiseconds)

Time (centiseconds)

 $I_{D+}; I_{eye}$ I_b I_{D+}

(caption on next page)



Virtual social networking increases the individual's

George Mengov^{a,*}, Nikolay Georgiev^a, Irina Zinovieva^b, Anton^a Faculty of Economics and Business Administration, Sofia University St. Kliment Ohridski, 125 Tsarigradsko
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Omnium bonum in Net

1_S1 Submission Dec 2018

2_N Submission July 2019

3_N Human Behav Submission Aug 2019

4_Nat Comms Sep 2019

5_Sci Rep Submission Sep 2019

6_Nature Neuroscience 2020

7_PNAS 2020

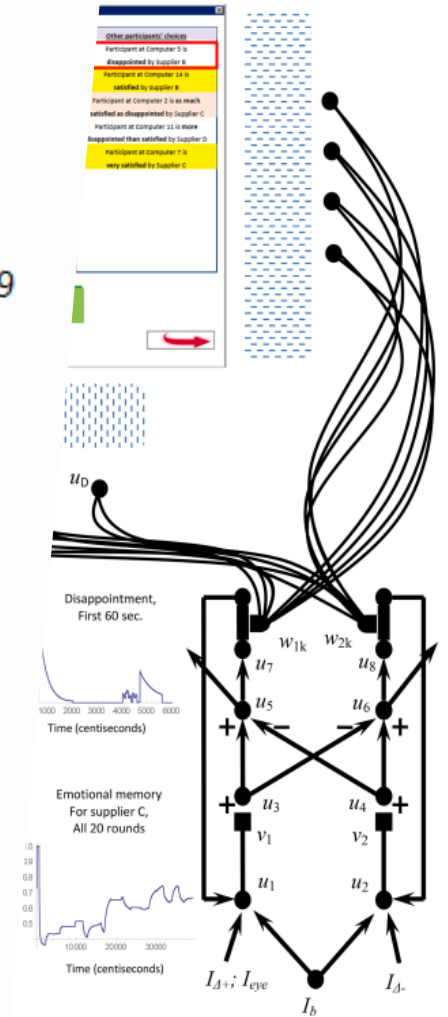
8_Royal Society 2020

9_Royal Society 2020b

10_Cog Sys Res 2020

11_JBEE 2020

11a_JBEE 2021



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Manuscript Number: JBEE-D-20-00081

Virtual

George

^a Faculty of E
^b Department

ARTICLE

Keywords:
Decision making
Virtual social
Emotional
Neural model

1. Introduction

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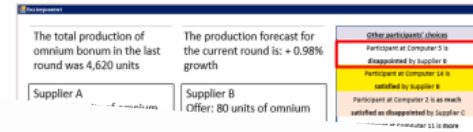
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A neural model forecasts emotional economic choice in a virtual social network

Dear Professor Mengov,

Thank you for submitting your manuscript to the Journal of Behavioral and Experimental Economics.

I have completed my evaluation of your manuscript. The reviewers recommend reconsideration of your manuscript following revision and modification. I invite you to resubmit your manuscript after addressing the comments below. Please resubmit your revised manuscript by Jul 25, 2021.

When revising your manuscript, please consider all issues mentioned in the reviewers' comments carefully; please outline every change made in response to their comments and provide suitable rebuttals for any comments not addressed. Please note that your revised submission may need to be re-reviewed.



(caption on next page)

Journal of Behavioral and Experimental Economics

Editor and Reviewer comments:

Associate editor's comments: Reviewer 2 made many constructive comments. Please follow them for the next revision.

Reviewer #1: This paper is a continuation of the author's ongoing work on applying to economic decision making a long-established methodology for understanding mental processes via neural network modeling. It makes a strong contribution by fitting a model to empirical preferences of experimental participants, and showing that the model reproduces some types of decision processes (emotion based, both short-term and long-term) better than other types (theory based).

Therefore the paper should definitely be published as is. The only change I recommend is on p. 13, where "nonmonotonous" should be replaced by "nonmonotonic," the preferred usage among English-speaking mathematicians.

poses an upper bound to its achievements.

One alternative is the bottom-up approach developed by mathematical neuroscience. It studies how neural circuits in the brain give rise to cognitive phenomena like emotion, memory, learning, etc. This endeavor has already identified the neural substrate of a variety of complex psychological processes. As the field matured, some researchers made pioneering attempts – initially at the conceptual level only – to envision what neurobiological structures in the human brain could be at

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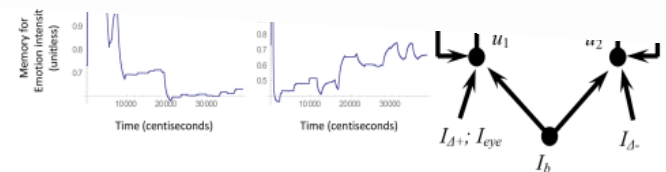
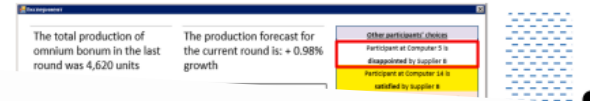
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Reviewer #2:

This paper proposes to link a brain neural model with behaviors in economic experiments.

In general, the paper needs to be rewritten in a more professionally structured form.

There are many terms mentioned without explanation, which is an issue for readers to comprehend the ideas.

The problem definition is lacking.

Also, there's a lack of benchmark for experiments.

This makes evaluation of the findings more difficult.

The following issues need to be resolved:

1. The major contribution of this work is unclear.

For example, Fig.1 seems to be the major neural model used in this work.

But it's not mentioned whether it's an existing model or a newly proposed one.

It's very important to distinguish between the proposed methods from existing ones.

There's no clear problem definition in the paper.

So it's difficult to evaluate the findings.

In Fig.1, it's not clear what does it mean by "neural circuit model".

Is it a real circuit or just a simulation in computers?

Why was the model designed in that way?

How do you link the meanings of neurons u_1, \dots, u_8 with positive and negative emotions

such as satisfaction and disappointment, emotional memories, and reflex conditioning?

Why are they only related to emotions?

2. Another major issue of this paper is the lack of related works and benchmark. For example, since there's no clear problem definition, the baseline is also lacking. Without comparison with existing methods, it would be difficult to judge the contribution of this paper.

3. There are many assumptions in the paper, which need very careful explanation. For example, under Eq. (11), it's assumed that at any moment, the participant can only pay attention to either the offers or the messages from others. This might not be realistic since people could also make decisions from both.

4. In the experiments, the model was calibrated on a person-by-person basis. But there could be too little data from a single participant for the model to learn. This is very different from current practices in machine learning. It should be carefully explained.

5. In Sec.4, the authors claim that the impressive forecasting of some people implies that they have made economic decisions mostly using emotions. Why? This is not reasonable. How can you be sure that it's not the result of some reasoning?



Virtual social networking increases the individual's economic predictability

6. In general, the writing needs to be greatly improved.
Also, the paper title needs to be modified.

For example, the term "neural model" in the title can be a little misleading nowadays for readers in different domains, since it could be related to the artificial neural networks as in deep learning community.

Regarding the term "virtual social network" in the paper title, it's not really social network since the participants receive all messages from others. There's no social relations or real interactions. It's more like reading some random messages, or listening to some rumors or gossips on the Internet.

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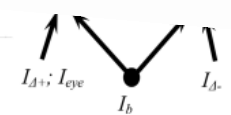
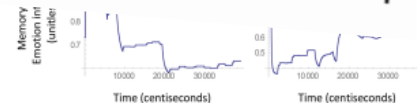
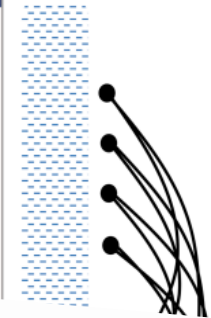
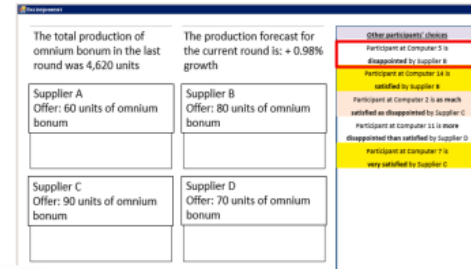
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vi Dear Professor XXX,

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Six months ago, my co-authors and I resubmitted our revised version of manuscript Number JBEE-D-20-00081_R1, with title, "Virtual social networking increases the individual's economic predictability". We understand that these are difficult times of covid pandemic, and sincerely wish you and our two reviewers to be healthy and well. But do you think that a decision on our manuscript could be reached in the foreseeable future?

Best Regards,

Prof. Dr. George Mengov

Dr. George Mengov

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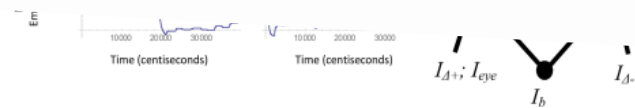
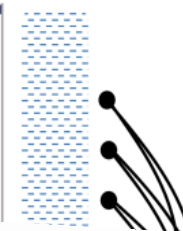
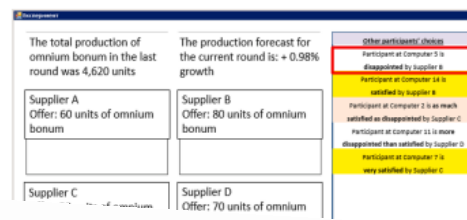
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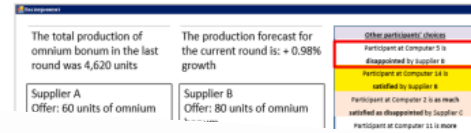
Dear Professor Branas-Garza,

I am the first author of Manuscript Number: JBEE-D-20-00081, which is under review after resubmission for 14 months now (since July 24, 2021). The action editor, Professor XXX has written to me a few times asking, "to wait for just a few more days", yet time goes by. Meanwhile, the publisher Elsevier requested that I fill in a questionnaire "for statistical purposes" about my race, gender, and country of origin, apparently identifying a case of discrimination. Indeed, my coauthors and I are East Europeans. Nonetheless, we might still have produced high-quality research. Dear Professor Branas-Garza, please take a decision on our paper.

Best Regards,

George Mengov

Professor George Mengov, Ph.D.
Faculty of Economics and Business Administration
Sofia University St. Kliment Ohridski
125 Tzarigradsko Chaussee Blvd., Bl. 3,
1113 SOFIA, BULGARIA





Virtual social networking increases the individual's economic predictability

George Mengov^{a,*}, Nikolay Georgiev^a, Irina Zinovieva^b, Anton Gerunov^a^a Faculty of Economics and Business Administration, Sofia University St. Kliment Ohridski, 125 Tsarigradsko Chaussee Blvd., Bl. 3, Sofia 1113, Bulgaria^b Department of Psychology, Sofia University St. Kliment Ohridski, 15 Tsar Osvoboditel Blvd., Sofia 1504, Bulgaria

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Emotional economic choice
Neural model

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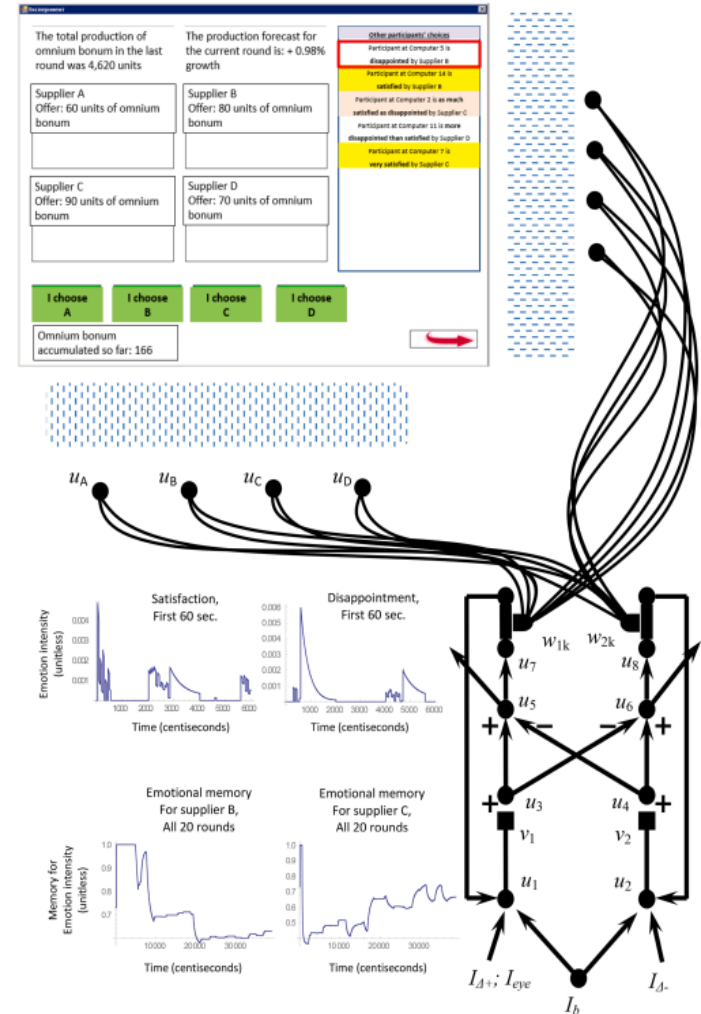
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Advice

- *In science, you must develop a thick skin.*
(Robert French)
- *I have always believed that scientific research is another domain where a form of optimism is essential to success: I have yet to meet a successful scientist who lacks the ability to exaggerate the importance of what he or she is doing...* (Daniel Kahneman)



A better way to start a paper

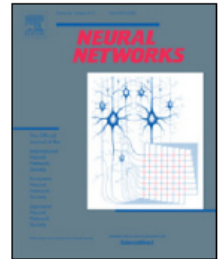
... is to solve a long-standing problem



Contents lists available at ScienceDirect

Neural Networks

journal homepage: www.elsevier.com/locate/neunet



A survey of adaptive resonance theory neural network models for engineering applications



Leonardo Enzo Brito da Silva^{a,b,*}, Islam Elnabarawy^a, Donald C. Wunsch II^a

^a Applied Computational Intelligence Laboratory, Missouri University of Science and Technology, Rolla, MO 65409, USA

^b CAPES Foundation, Ministry of Education of Brazil, Brasília, DF 70040-020, Brazil

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Classification

Regression

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Survey

ABSTRACT

This survey samples from the ever-growing family of adaptive resonance theory (ART) neural network models used to perform the three primary machine learning modalities, namely, unsupervised, supervised and reinforcement learning. It comprises a representative list from classic to contemporary ART models, thereby painting a general picture of the architectures developed by researchers over the past 30 years. The learning dynamics of these ART models are briefly described, and their distinctive characteristics such as code representation, long-term memory, and corresponding geometric interpretation are discussed. Useful engineering properties of ART (speed, configurability, explainability, parallelization and hardware implementation) are examined along with current challenges. Finally, a compilation of online software libraries is provided. It is expected that this overview will be helpful to new and seasoned ART researchers.



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Classification
Regression
Reinforcement learning
Survey

In Wunsch II (2009) the conjecture is made that the dichotomy of match-based learning (i.e., Hebbian learning and ART) and error-based learning (i.e., using backpropagation (Rumelhart, Hinton, & Williams, 1986; Werbos, 1974, 1990) in feed-forward neural networks (Haykin, 2009) such as deep learning architectures (Goodfellow, Bengio, & Courville, 2016)) is likely a false one. This still lacks a definitive resolution. Some contributions

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helpful

parameters
compilation of online software libraries
to new and seasoned ART researchers.

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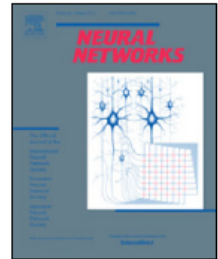


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A survey of adaptive resonance theory neural network models for engineering applications



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Regression

Reinforcement learning

Survey

ever, the problem of building a system that can do both match- and error-based learning like animals appear to be capable of remains a more complex and interesting challenge that holds great promise for much more stable and effective machine learning.

pretation are discussed. (General engineering and hardware implementation) are examined along with current state-of-the-art. A compilation of online software libraries is provided. It is expected that this overview will be helpful to new and seasoned ART researchers.

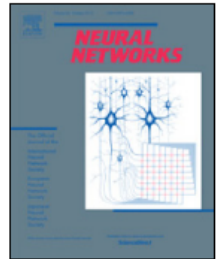


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A survey of adaptive resonance theory neural network models for engineering applications

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ing. The ability to master both types of learning and resolve this conjecture is believed to be a gateway to building machine learning systems that are fast and stable, possessing the ability for life-long learning and being resilient in the face of unpredictable changes in the environment.

Regression
Reinforcement learning
Survey

parallelization and hardware support. A compilation of online software libraries is provided. It is expected that this overview will be useful to new and seasoned ART researchers.

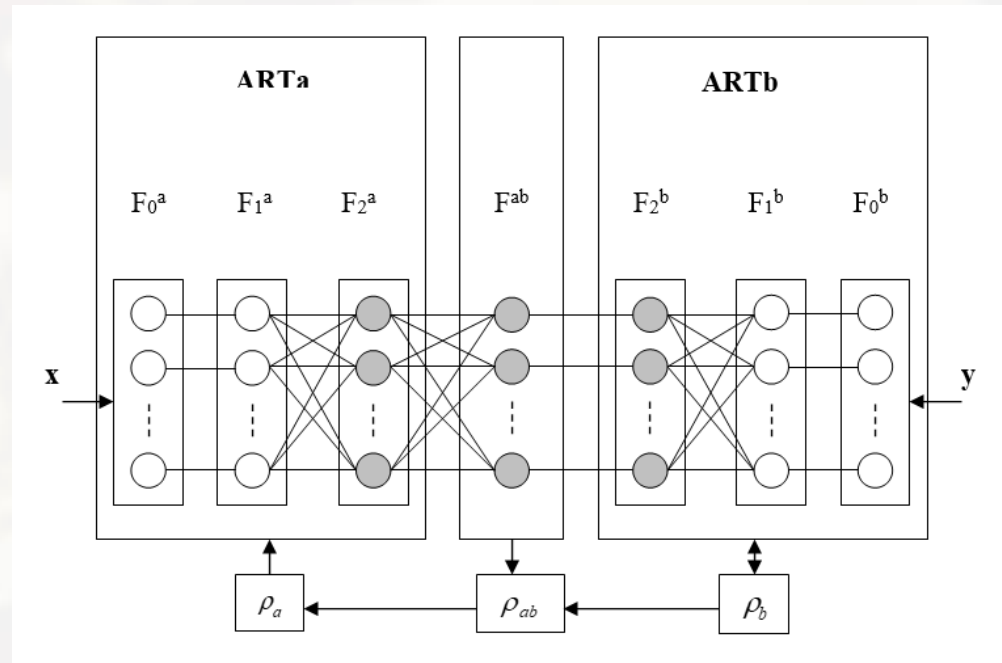
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ARTMAP NN

Computes

$$y = f(x)$$

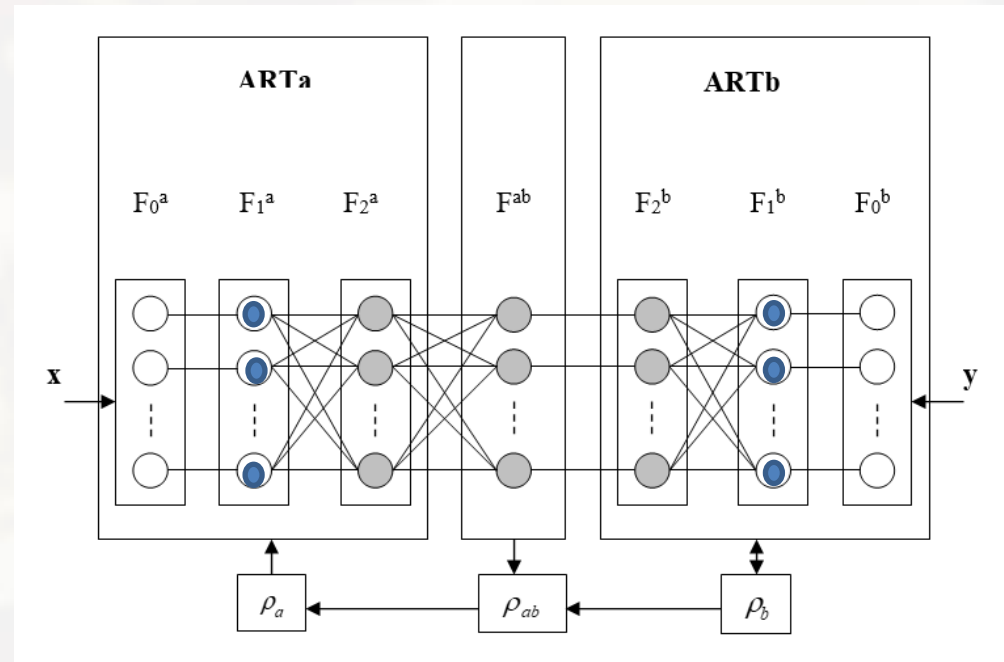
Creates input and
output clusters



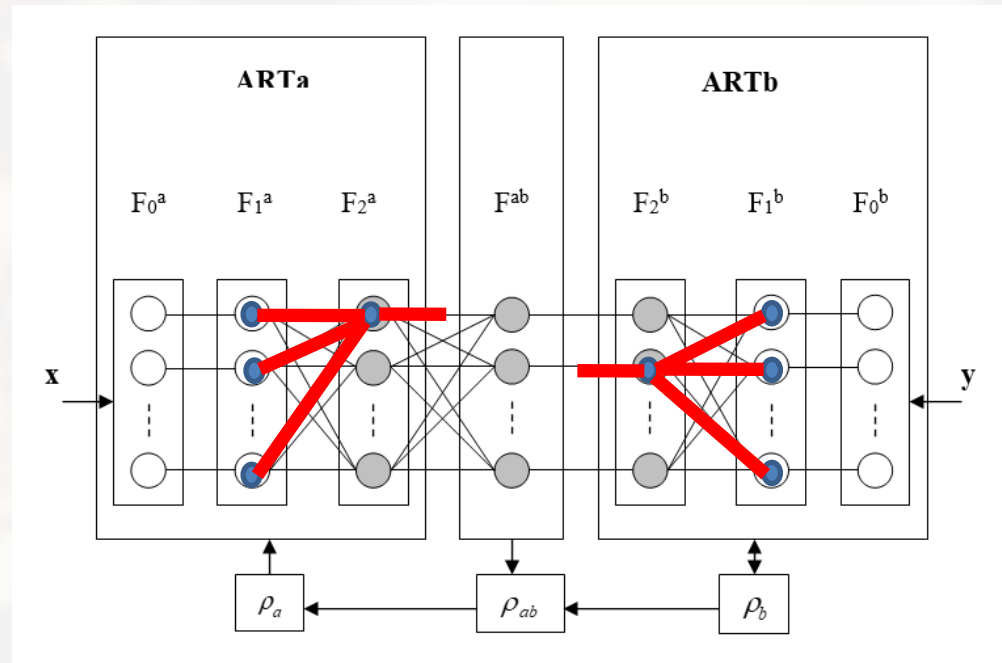
Each ART module performs ‘hypothetico-deductive reasoning’.

The NN ‘knows’ if it has seen this \mathbf{x} , or similar, before. (E.g., “Similarity of 91%”).

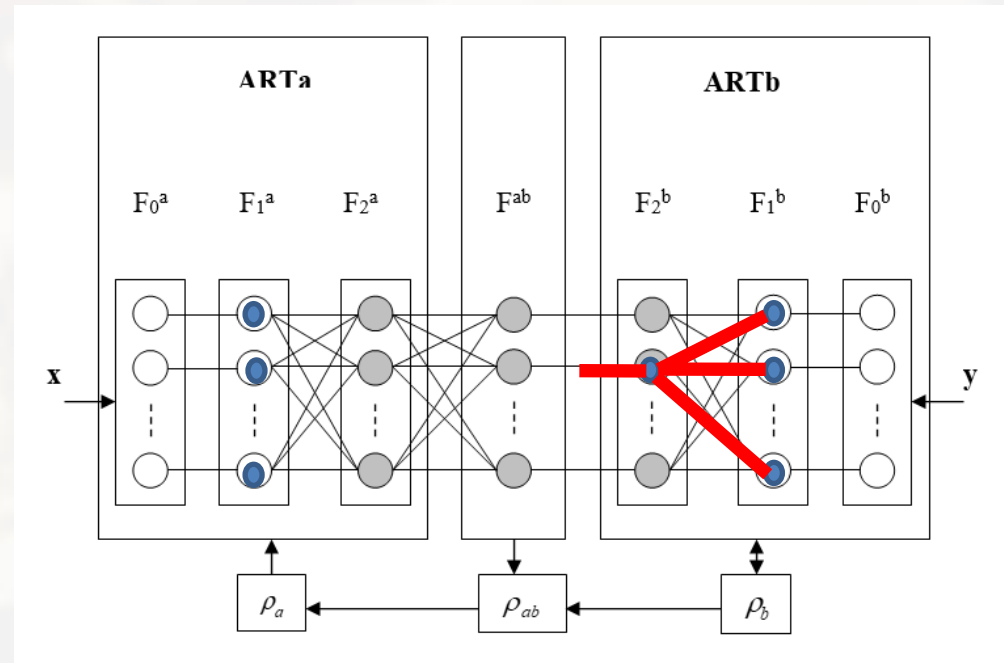
The same about \mathbf{y} .



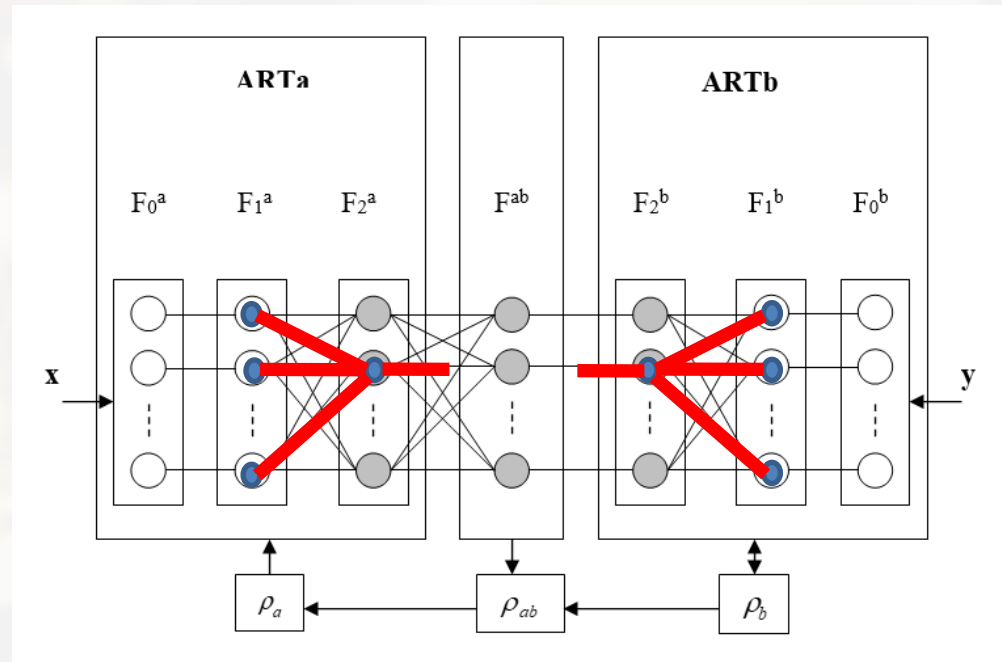
Hypotheses are made about the I/O mapping



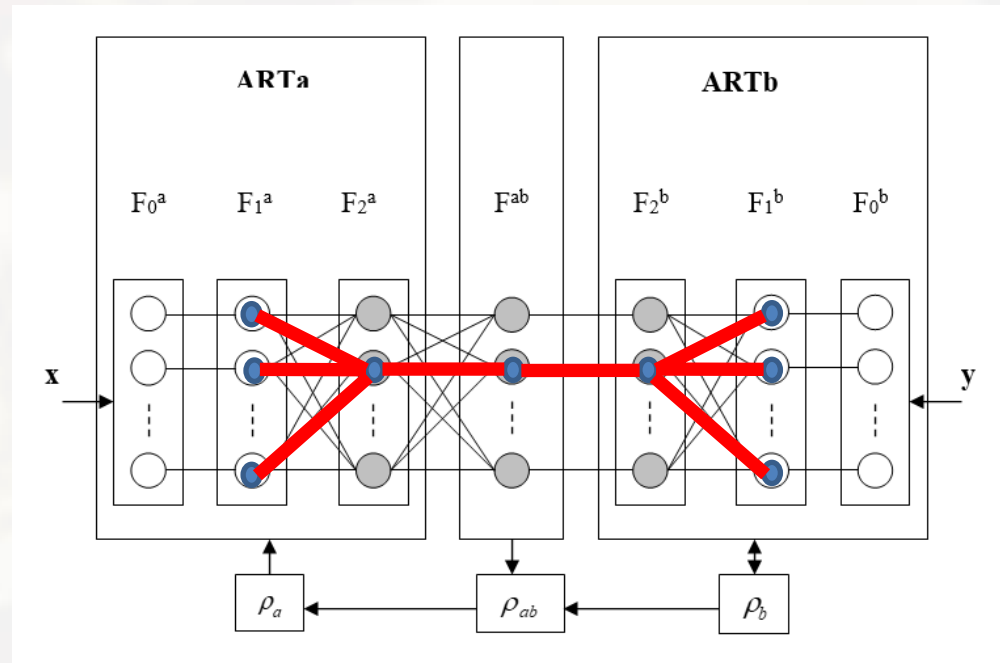
When a hypothesis is turned down...



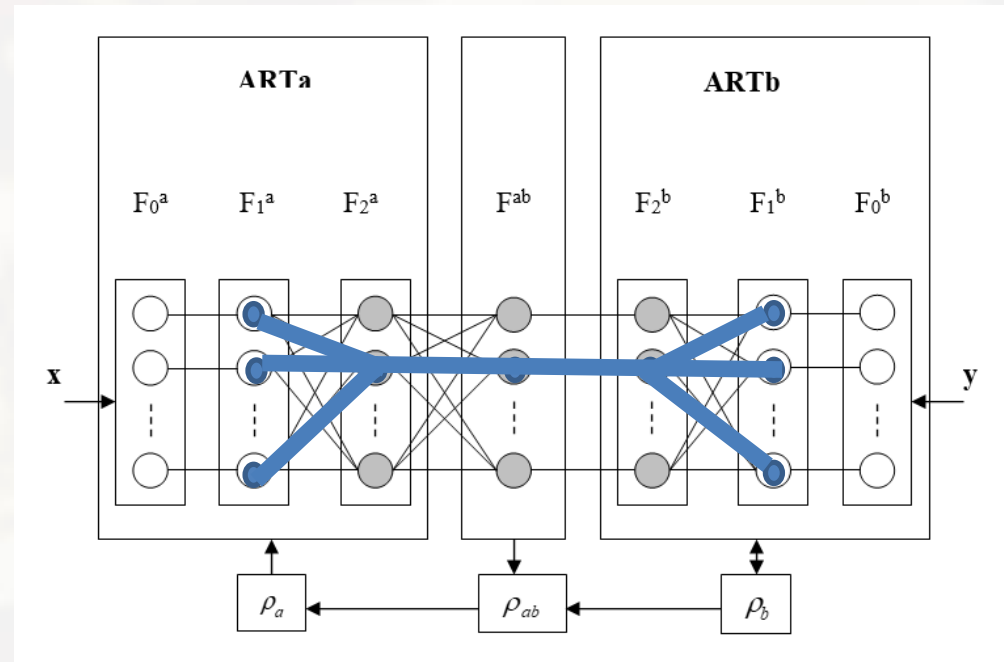
... a new one is made.



Eventually, a correct matching is identified.

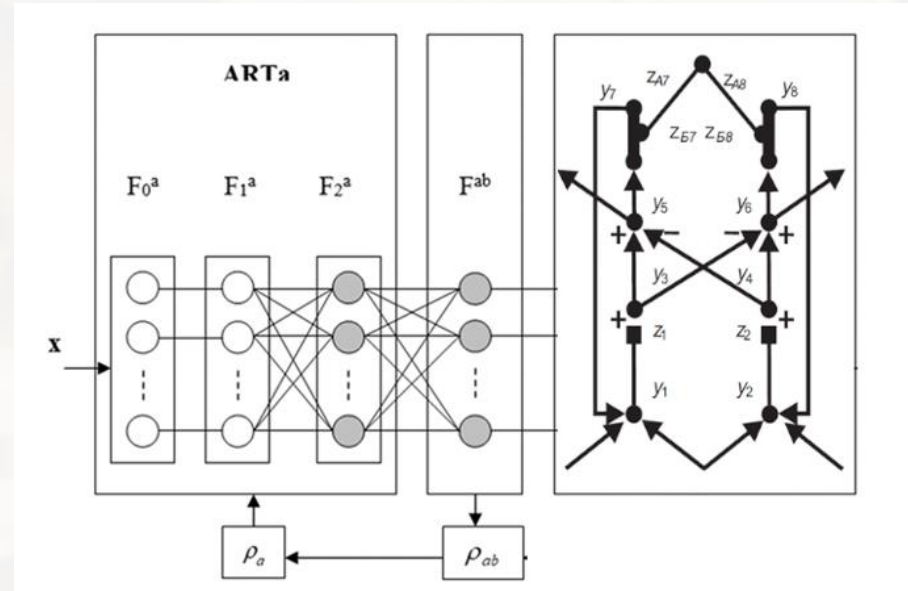


And learning takes place.
(The relevant connections among neurons are changed.)



- The ARTMAP NN has huge advantages and one handicap –
- It could not perform error-based y-value learning
- But only class-membership learning

- A new NN is proposed...
- And should be tested with
 1. Interesting problems and
 2. Difficult data



The first stage in preparing a manuscript

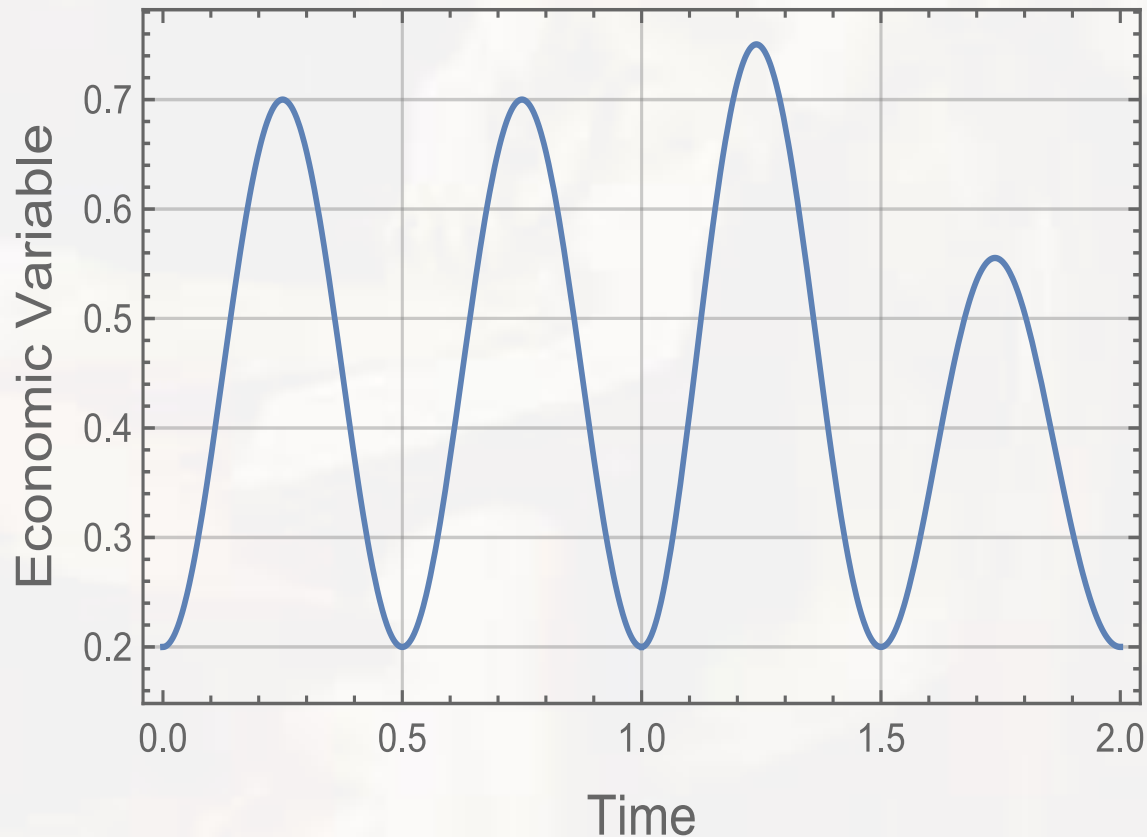
- (After all research work is done)
- Tables
- Figures

The Lucas Critique

In the economy, if you have a forecasting model, and it is working, it is no longer working.

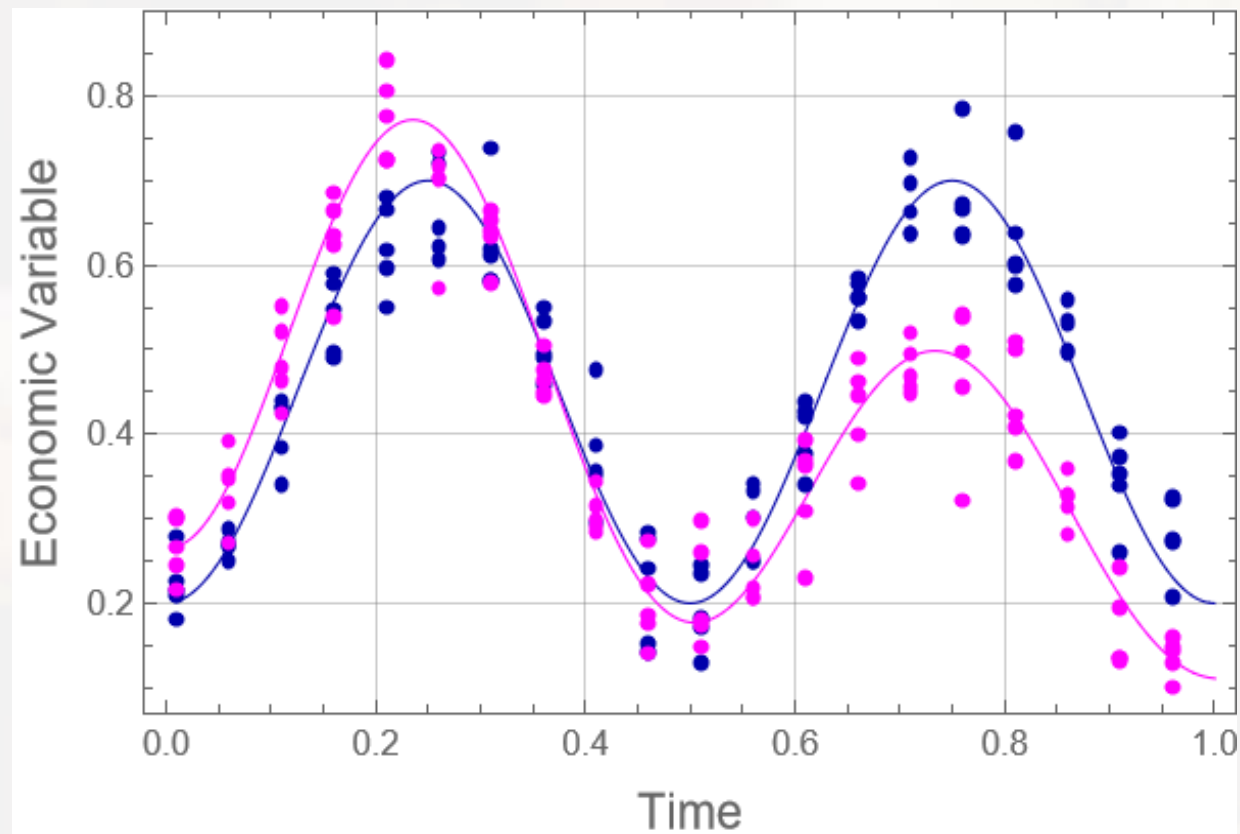
(A paraphrase of a statement by Robert Lucas)

An abstract economic process – after two regular cycles the agents rush and overshoot in cycle 3, leading to a slump in cycle 4.

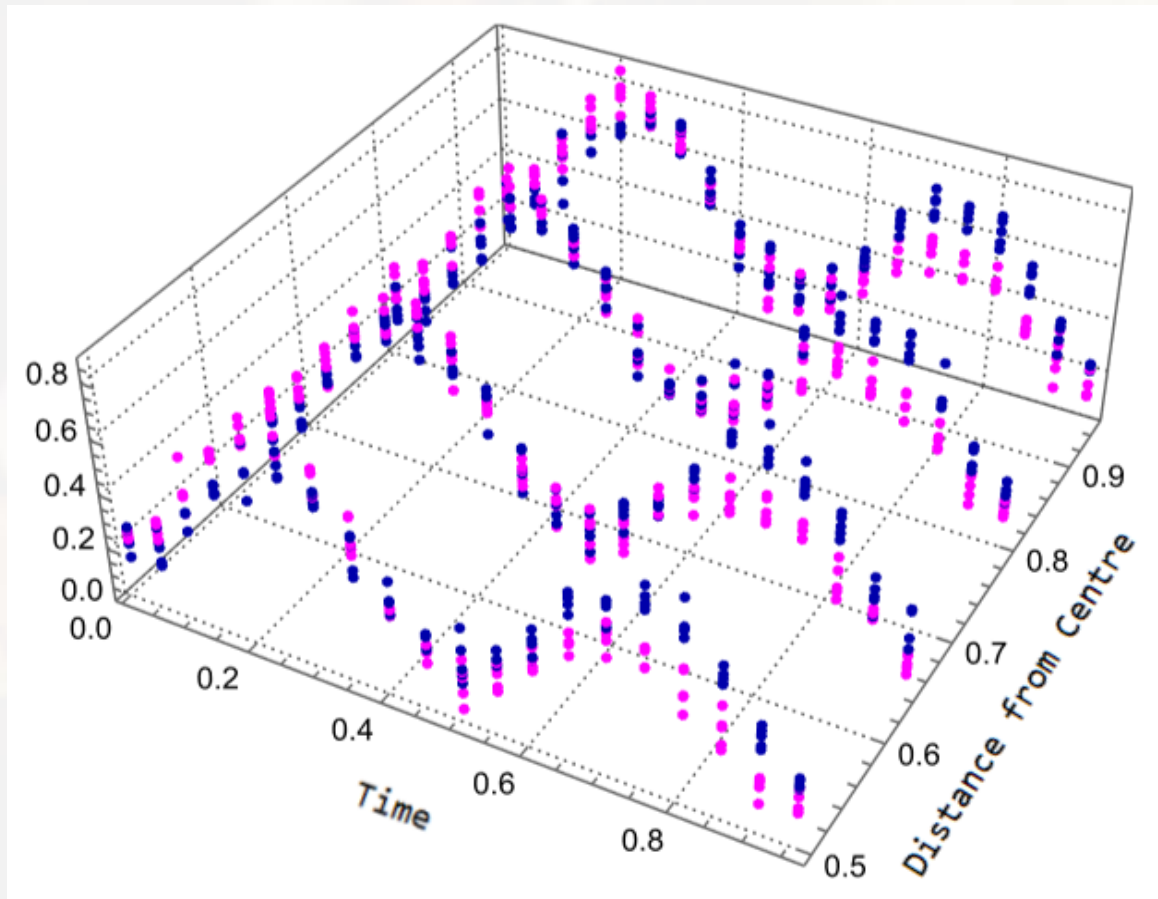


The economic variable (prices, traded volumes, interest rates, etc) has five values at each transaction moment.

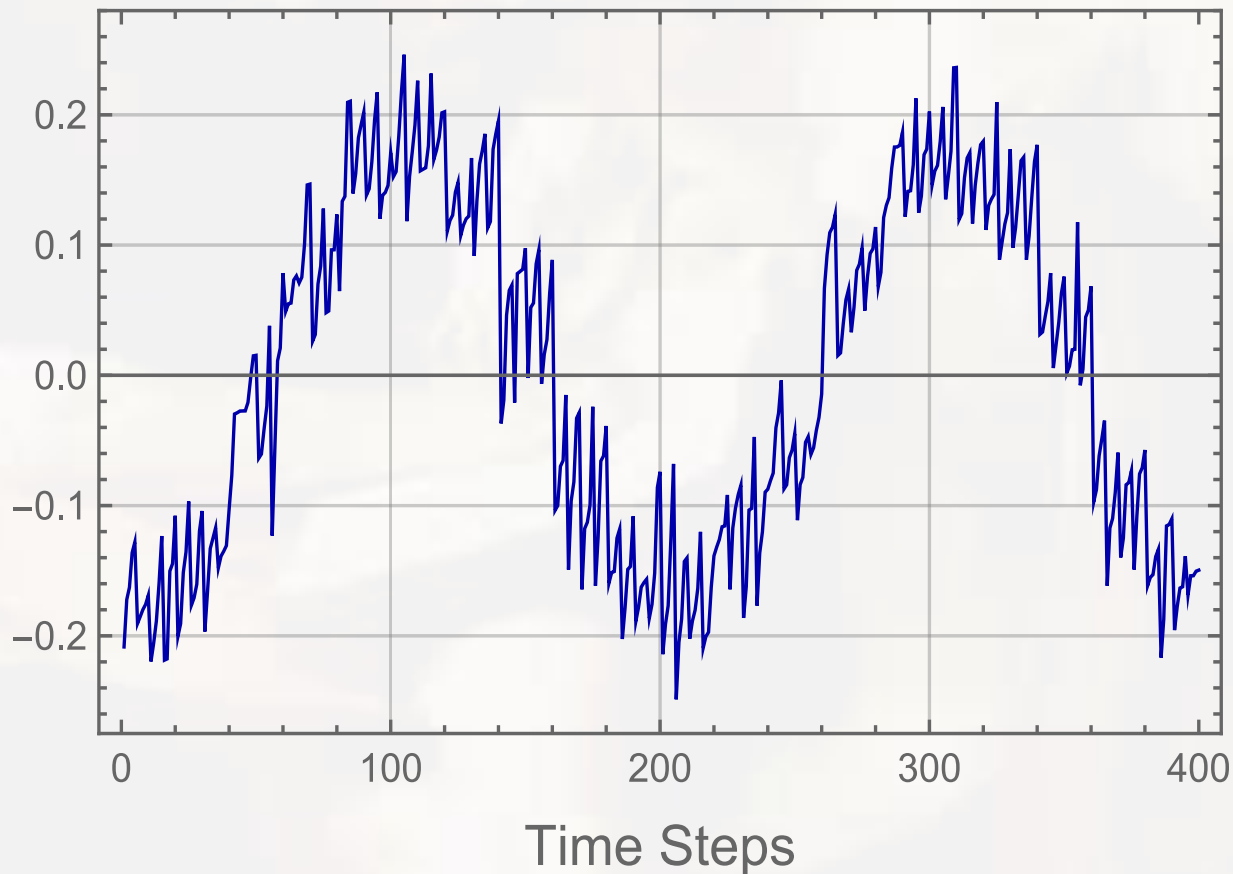
Blue colour indicates the first two regular cycles, magenta the last two imbalanced cycles.



There are four market locations of different size



Data, actually submitted to the neural network, are ordered in time and from largest to smallest market (only the two regular cycles are shown)



The NN's internal memory

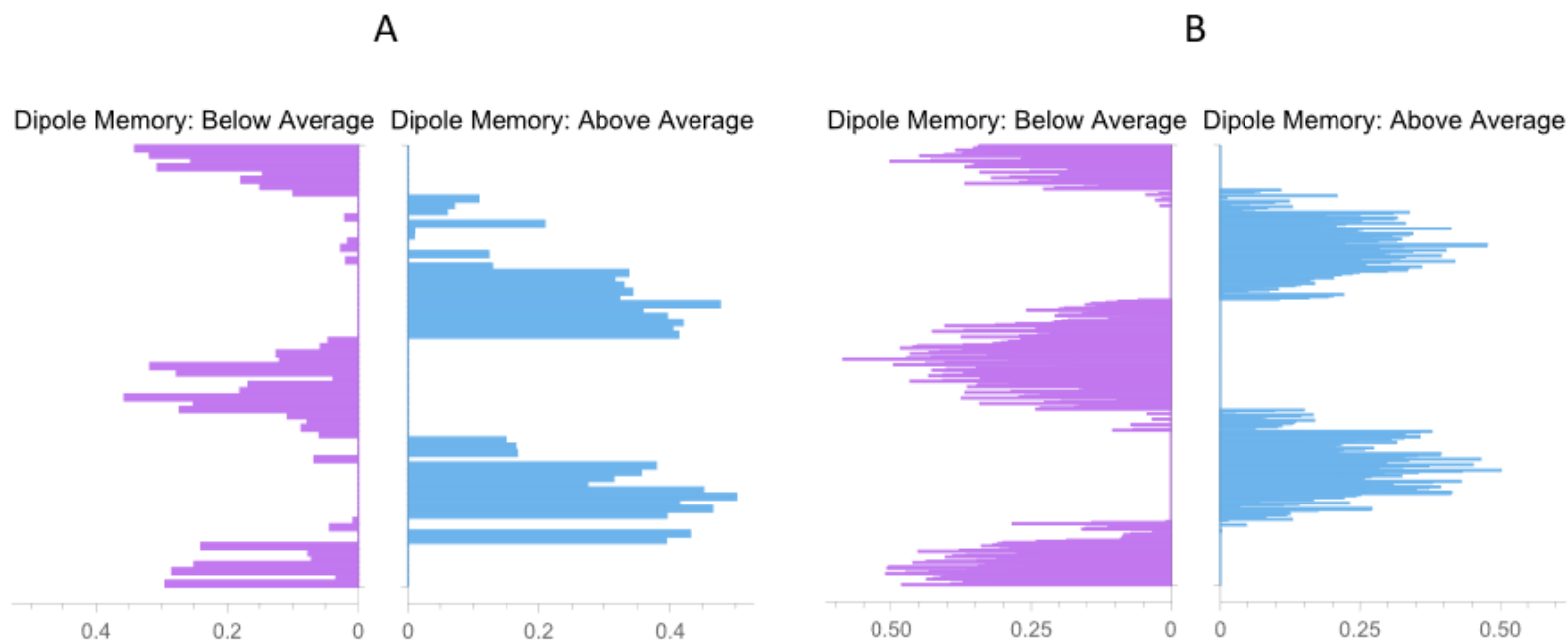


Figure 3. Dipole memory after one epoch of WTA training. **A.** 71 categories, $\rho = 0.75$ and $r = 0.5$. **B.** 400 categories, $\rho = 1.0$ and/or $r = 0.005$.

Figure 4c is the happy end

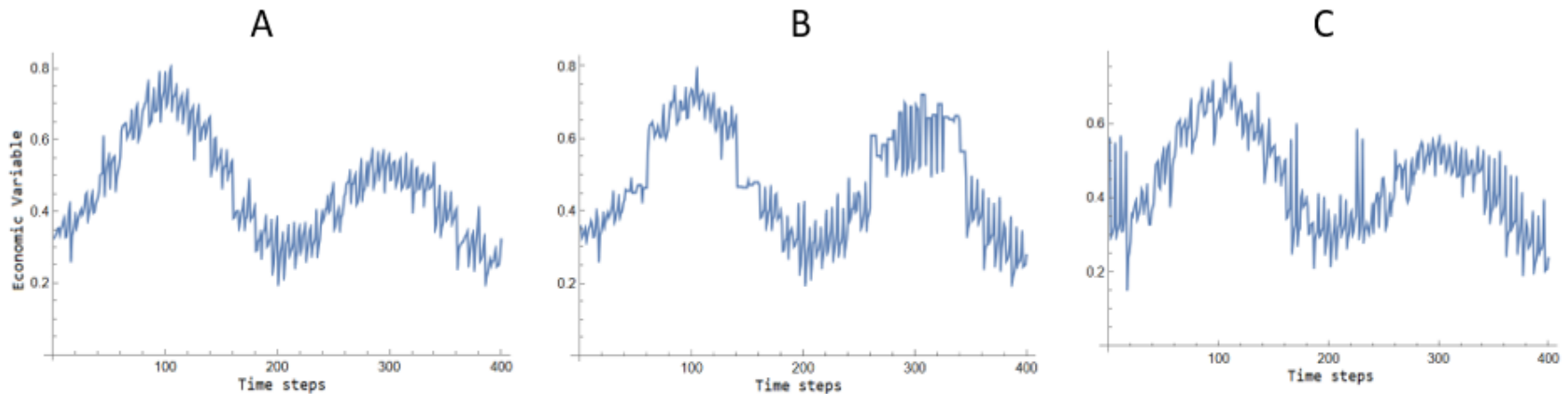
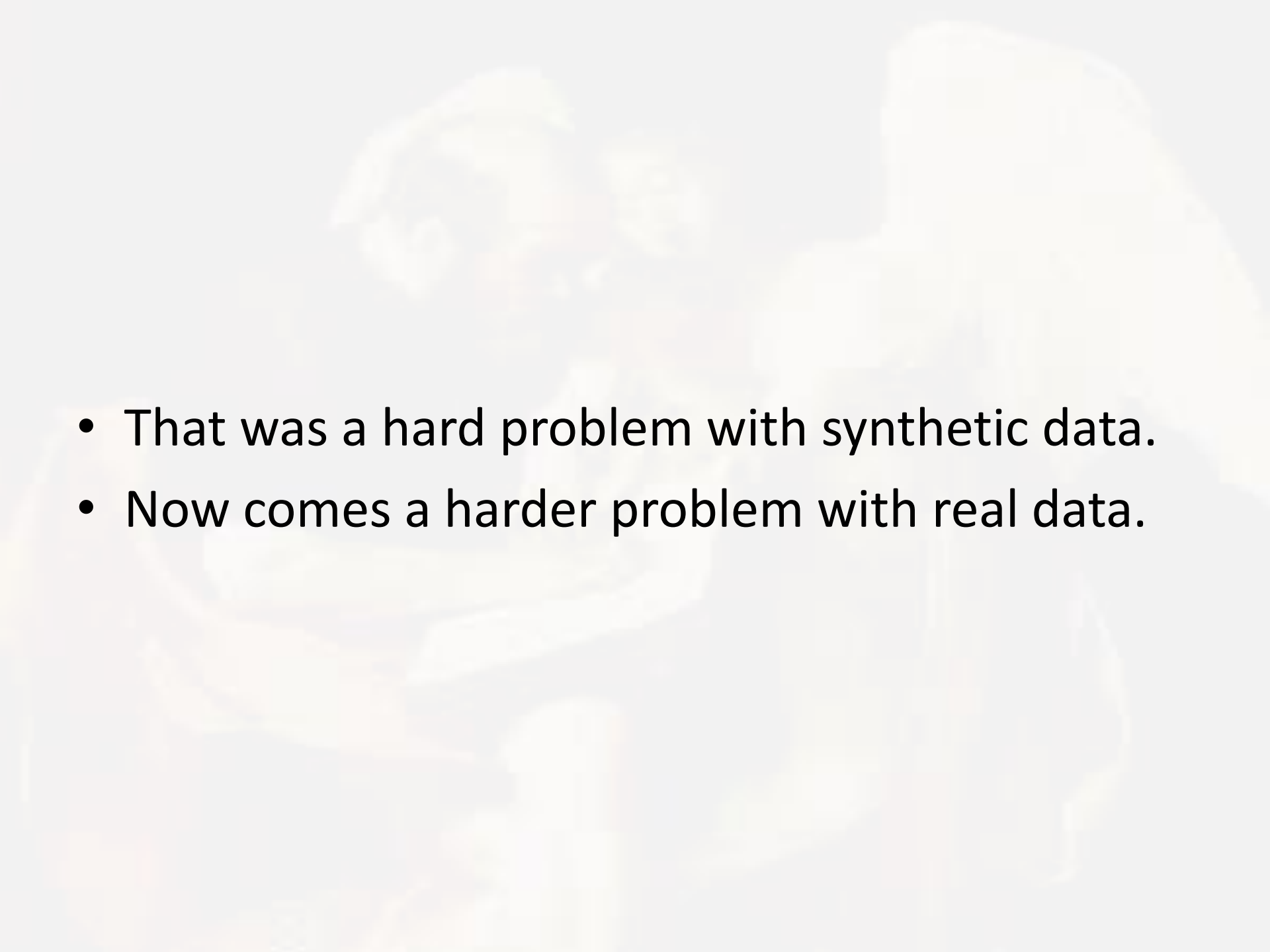


Figure 4. Neural network performance. **A.** Imbalanced cycles 3 & 4 data as submitted. **B.** Forecast ex-ante during WTA learning. **C.** Forecast ex-ante during distributed learning.

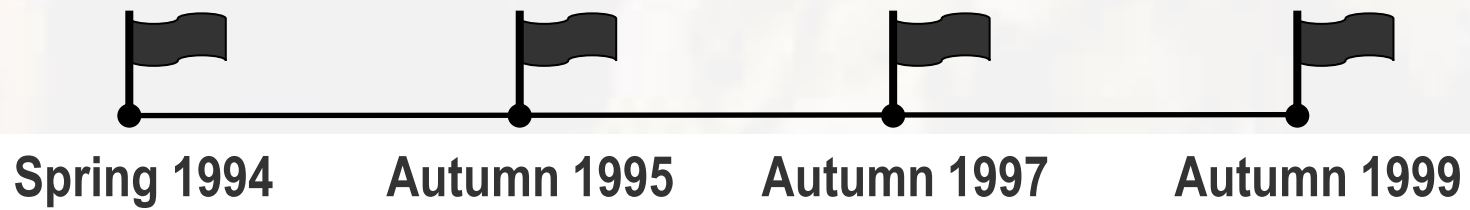
- 
- That was a hard problem with synthetic data.
 - Now comes a harder problem with real data.

A study in work motivation and professional life, Bulgaria 1994 - 1999

- Comprehensive measurement instrument from work and organizational psychology
- 49 psychological and 4 demographic variables, 450 items
- Representative sample of 1107 people
- Longitudinal, 4 waves

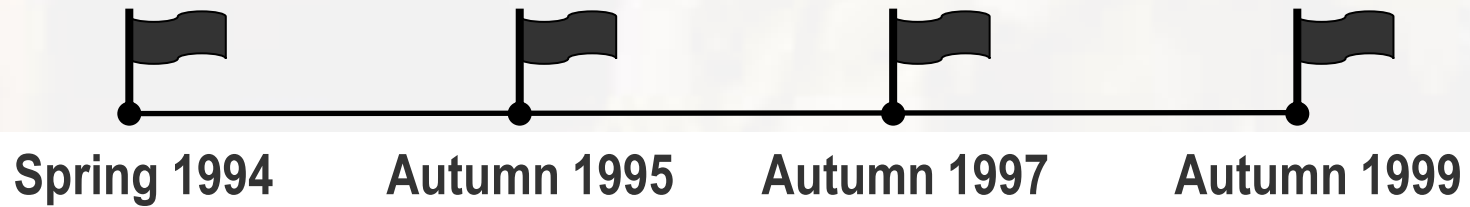


1058% inflation in 1997



1058% inflation in 1997

Fundamental
economic restructuring



1058% inflation in 1997

Fundamental
economic restructuring



Spring 1994

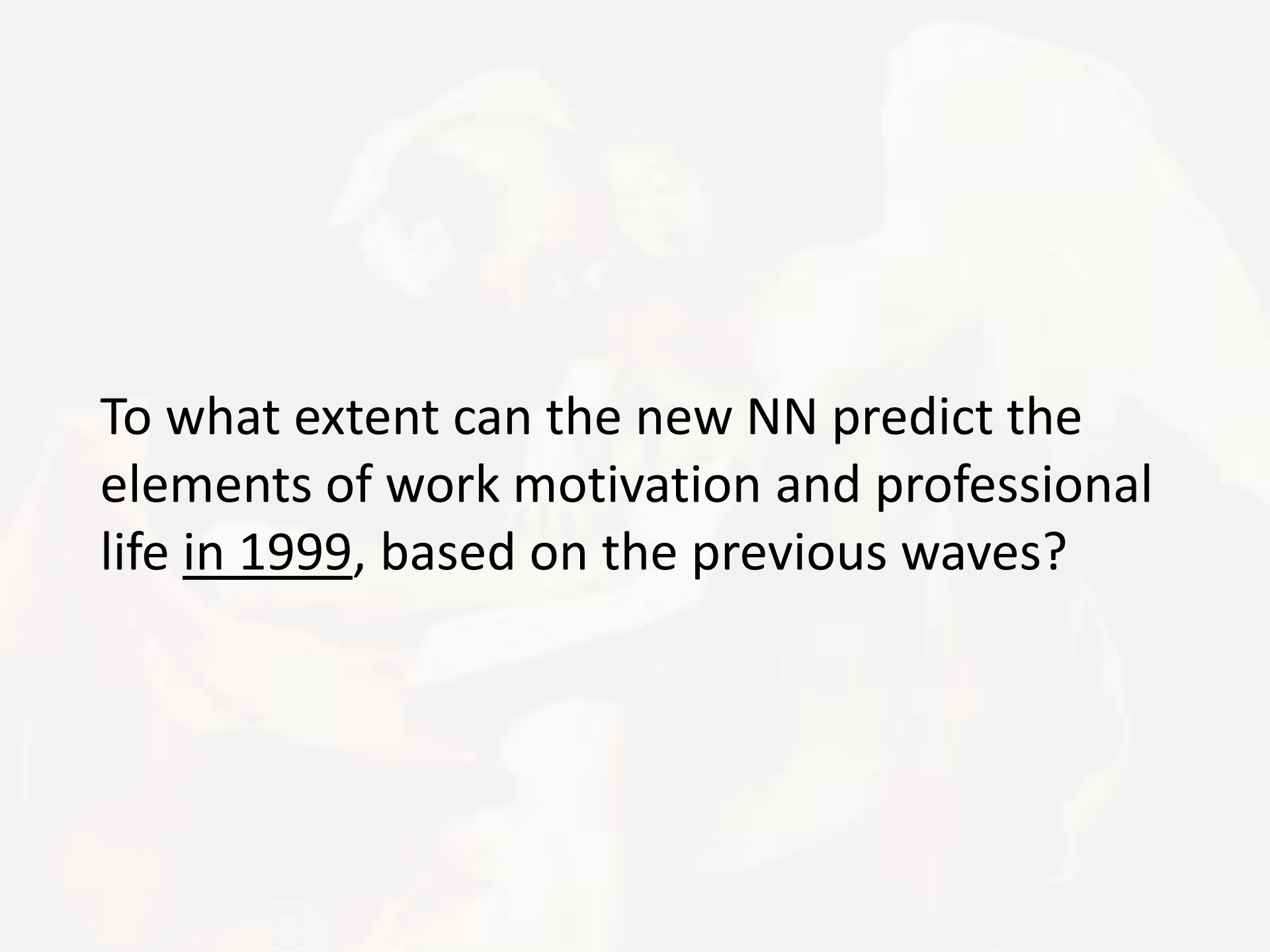
Autumn 1995

Autumn 1997

Autumn 1999

In-Sample,
Training Sample,
Calibration Sample

Out-of-Sample,
Test Sample



To what extent can the new NN predict the elements of work motivation and professional life in 1999, based on the previous waves?

An example:

- What predicts General Job Satisfaction
 - Socioeconomic wellbeing
 - Previous General Job Satisfaction
 - Opportunity for Personal Growth
 - Task Identity
 - Career Opportunities

Examples: A few people



Figure 6. Examples of input data for General Job Satisfaction (SA) forecasting. (Panel data, input variables are from moment t , output SA is from $t + 1$). **A.** A person who assessed their job satisfaction, personal growth, and career opportunities way above average despite a low socio-economic wellbeing. **B.** A person feeling somewhat dissatisfied with their job although all other

I/O data plots (only 2 of 5 predictors are shown)

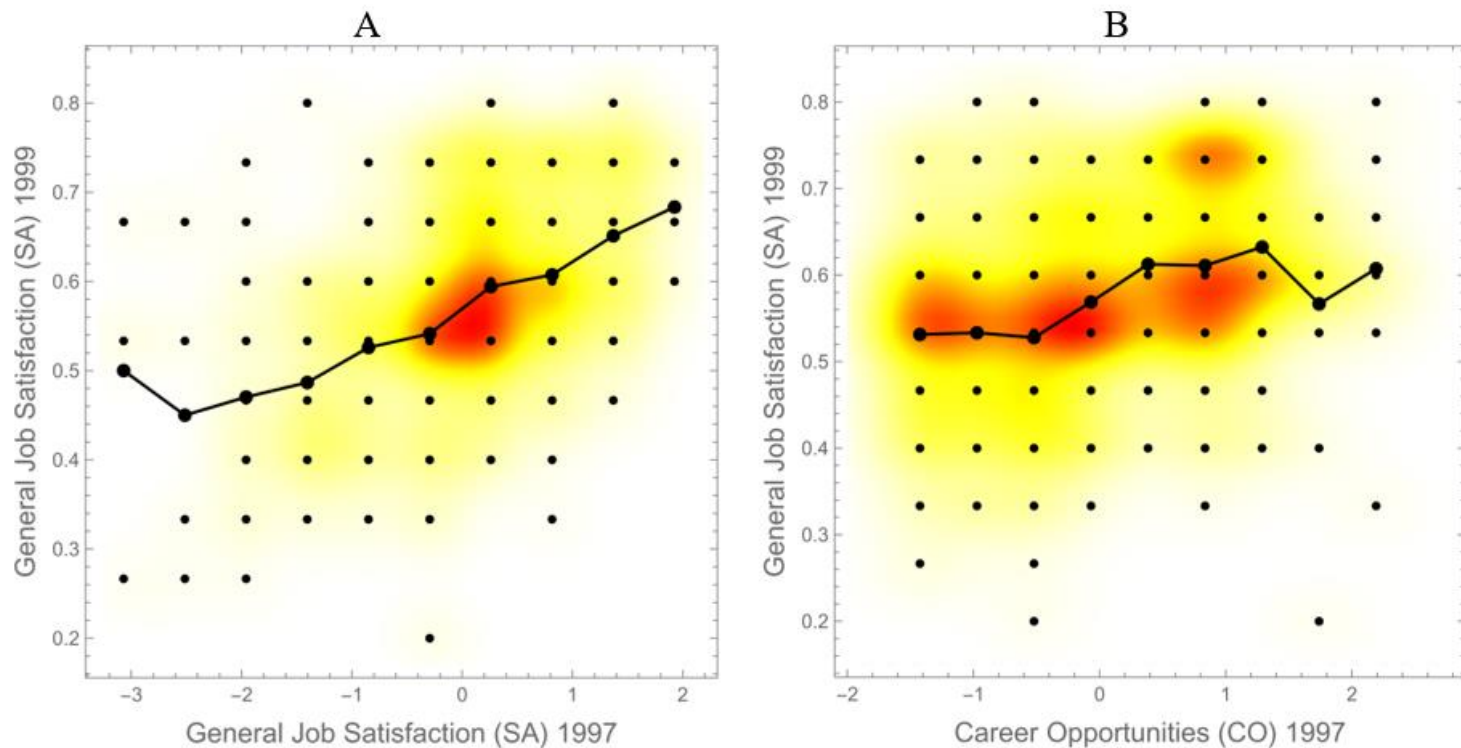


Figure 5. Data for General Job Satisfaction (SA). Small dots are empirical observations. Bigger dots are column averages. Joining lines highlight tendencies. Red and yellow colours indicate data concentration, i.e., areas with more people behind a single small dot. Two out of five predictors for SA are shown.

In some cases, the NN is visually successful,
numerically – not so much

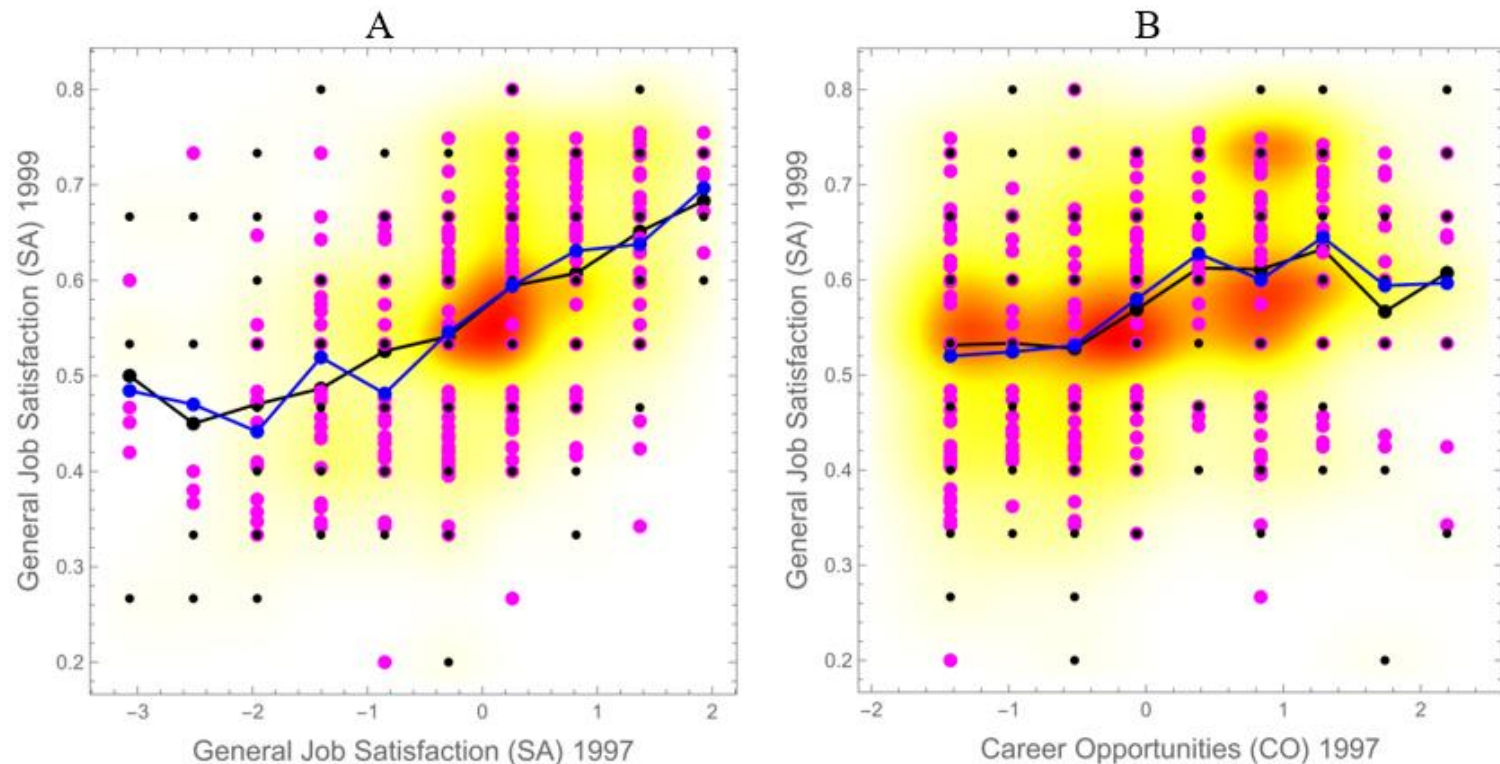


Figure 8. Forecasting General Job Satisfaction (SA) in 1999 – two predictors are shown. A single-neuron forecast after two WTA training epochs with 1994/95/97 data. Small and bigger black dots are as in Figure 5. Magenta dots are predicted observations, blue dots are column averages over predicted values. Joining lines highlight the tendencies.

The numerically best result

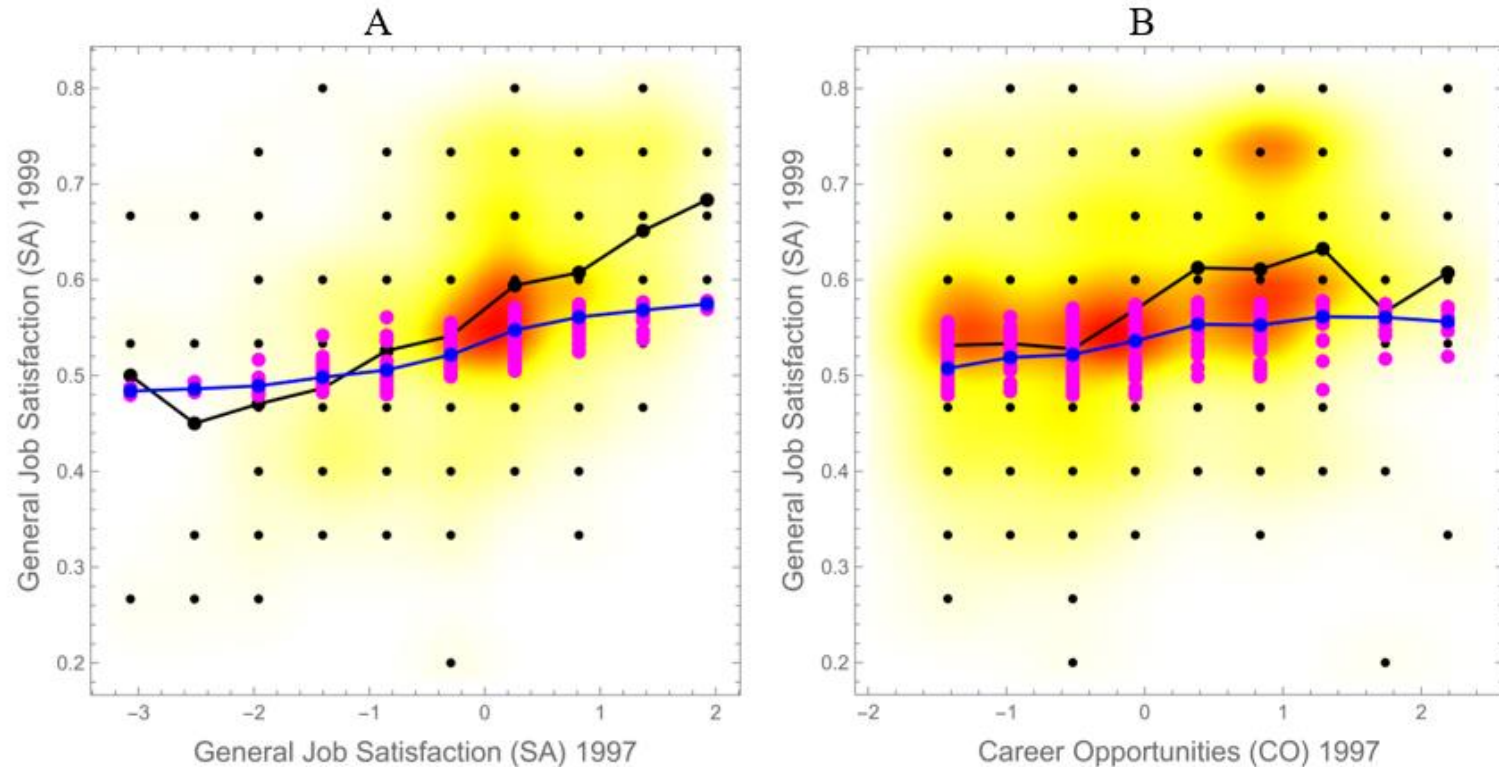


Figure 9. Forecasting General Job Satisfaction (SA) in 1999 after one WTA epoch followed by one distributed training epoch. **A** and **B**. The best result, $R = 0.5036$, is achieved by a 100-neuron forecast. **C** and **D**. A tiny bit worse, yet visually more compelling result is $R = 0.5017$, by a 200-neuron forecast.

And the second best result

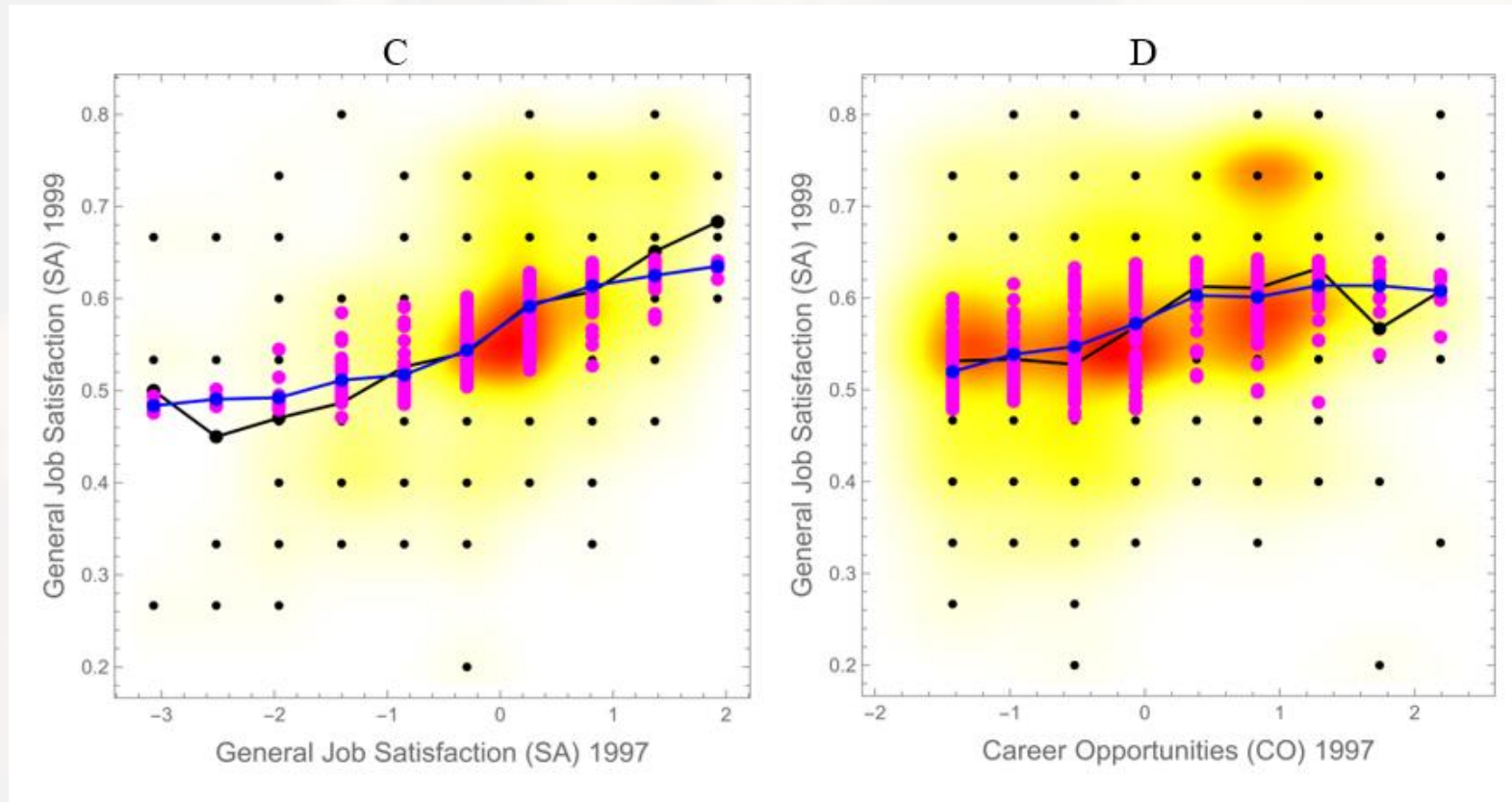


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The Title...

A dART-Dipole neural system with
error-minimization learning

The Title...

An efficient error-minimizing dART-Dipole neural network

A computationally efficient and explainable dART-Dipole neural network

A dART-Dipole neural network combining match-based and error-based learning

The Title...

dART-Dipole: A computationally efficient,
explainable, and novelty-detecting function
approximator

Concluding Advice

- Have what to say
- Organize it well
- Leave out a lot
- Be optimistic

Thank you!

