# POST-DIGITAL - European Training Network on Post-Digital Computing [GA860360]

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| CO | Confidential, only for members of the consortium (including Commission Services | |

## Project Details

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# EXECUTIVE SUMMARY

The Second year POST-DIGITAL workshop took place on 22 and 23 March 2022 in Groningen, Netherlands. It was organised by Prof Herbert Jaeger from University of Groningen and CogniGron- Groningen Cognitive Systems and Materials Center. This event was held in person and was co-located with the Mini-Symposium "Scaling up Systems and Application Complexity in Analog Neuromorphic and Physical Computing", which took place on 24 March 2022. These two events presented a unique opportunity for the POST-DIGITAL consortium to meet over 3 days in person for project related discussions and presentations. All 15 POST-DIGITAL ESRs took part in the 2nd year workshop in person.

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| | |
|---|---|
| AiPT | Aston Institute of Photonic Technologies |
| EC | European Commission |
| ESR | Early Stage Researcher |
| ETN | European Training Network |
| POST-DIGITAL | Project 'POST-DIGITAL - European Training Network on Post-Digital Computing' EC GA 860830 |

# 1 SECOND YEAR POST-DIGITAL WORKSHOP

The second year POST-DIGITAL workshop was originally planned on 26 and 27 January 2022. At this time the number of coronavirus new infections escalated across Europe and new travel restrictions were introduced in several countries including Netherlands. As the organiser University of Groningen and the POST-DIGITAL consortium members were interested in a face-to-face, interactive meeting, the event was postponed until March 2022 when the project members could meet in person over 3 days for the 2nd year POST-DIGITAL workshop (on 22 and 23 March 2022) and the Mini-Symposium Scaling up Systems and Application Complexity in Analog Neuromorphic and Physical Computing (on 24 March 2022). This was a unique opportunity not only for presenting interim research results but mainly for an interdisciplinary exchange with a lot of discussions in an interactive and constructive atmosphere.

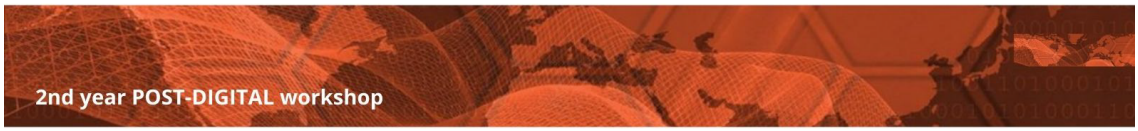
A nice addition to the 2nd year POST-DIGITAL workshop was the welcome dinner organised by the beneficiary University of Groningen. It gave the POST-DIGITAL team the opportunity to socialize, facilitate new discussions and collaborations, foster the exchange of ideas and experience and consolidate the project network.

The first day of the workshop started with an introductory talk given by Prof. Herbert Jaeger who guided the audience through a brief history of computing. Starting with Aristotle's syllogisms towards Boolean logic and concluded in Alan Turing‘s brilliant theory of the so called Turing-Machine. The introduction was followed by talks ranging from dynamical system theory to Concurrency theory in computer science. The first day was rounded up with presentations given by the local Post-Digital ESRs Guillaume Pourcel and Steven Abreu. Guillaume showed how questions of neurosymbolic integration motivate his work with Conceptors, whereas Steven presented his work on the DynapSE2 chip, a neuromorphic chip implementing up to 1000 analog spiking neurons.

The second day of the workshop was more interactive and asked the participants to discuss first in groups questions like "How to extend the formal theory of unconventional computing?" or "Where do we find applications for neuromorphic (optical) computing?". The results of the group discussion were presented in short 10 minute pitches followed by a long discussion. Thus, this event was a good training in teamworking skills, presenting and defending scientific results and was a nice complementation to the different skills the ESRs gained in local training courses and in the Transferable Skills Workshop 1, like Scientific Writing (provided by Dr Rachel Wong, international editor of Nature Photonics and Prof Srikanth Sugavanam from School of Computer and Electrical Engineering at IIT Mandi, India) and Presentation skills (delivered by Skillfuence). More information on the courses provided in the TSW I can be seen in the deliverable report D6.1 1st year POST-DIGITAL workshop and TSW I.

Co-located with a mini-symposium with four international speakers from fields like optical computing, material learning, and spiking neural networks, the 2nd year POST-DIGITAL workshop in Groningen was a thought-provoking experience for the entire consortium, discussing clearly the hard questions of scalability, digital and non-digital integration, theory of computing and many more.

## 1.1 AGENDA




**Agenda**

**Monday March 21, 19:00:**
pre-workshop welcome dinner at the Pannekoekschip

**Tuesday March 22, 9:00 – 17:00:**
Day 1 of PhD workshop Venue: Room 165 in the Linnaeusborg
We will be totally flexible – the following timetable is indicative only. We have scheduled more break time than usual – we'll use that "spare" time as we decide is best
9:00 – 9:10: Welcome
9:10 – 10:30: Herbert Jaeger: "Computing – what might that mean?" An attempt to turn a riddle into a tutorial
10:30-11:00: Break

11:00 – 12:00 Steven Abreu: The pains and powers of spikes (programming methods, analog neuromorphic processors, possibly demo)
12:00 – 14:00 lunch break (vouchers for the "Food Court" on the campus will be dealt out)
14:00 – 14:45 Jorge Perez (CS, Bernoulli Institute, https://www.jperez.nl/): Rigorous modeling of message-passing concurrency - an overview (for non-CS audience)
14:45 – 15:00 break
15:00 – 15:30 Hildeberto Kojakhmetov (mathematics, Bernoulli Institute, https://hildejk.com/): Multiple time scales in nature and an approach to model them
15:30 – 16:00 break

16:00 – 17:00 Guillaume Pourcel: Conceptors, Cognition, Computing

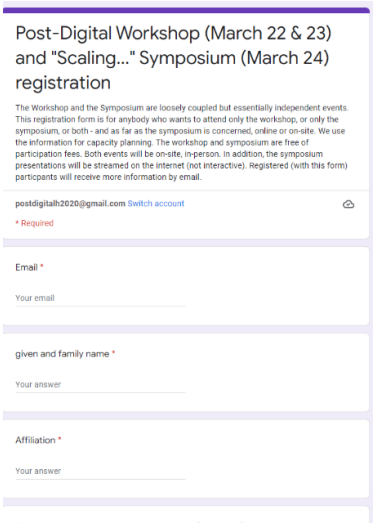
**Wednesday March 23, 9:00 – 17:00:**
Day 2 of PhD workshop
Venue: Bernoulliborg 134 (for forum gathering), + several small meeting rooms and offices in the Bernoulliborg
The idea for this day 2 of the workshop is to do things rather than to listen to things. We split into 3 (or 4) groups, each of which works out highlight views on a PostDigital topic (seven topic proposals are at the end of the schedule). These "highlight views" can be questions for conceptual clarification, perceived technological challenges, visions for applications, warnings for social implications, - whatever is apt to sharpen our thinking about the respective theme.

9:00 – 9:30 Intro to the activities of this day; formation of 3 groups, each choosing one discussion theme
9:30 – 12:00 Group work with self-decided breaks (at the end, material for a 5-10 min pitch should be ready, and a speaker chosen)
12:00 – 14:00 Lunch break
14:00 – 14:45 group 1 reports; discussion in forum
14:45 – 15:00 break
15:00 – 15:45 group 2 reports; discussion in forum
15:45 – 16:15 break
16:15 – 17:00 group 3 reports; discussion in forum

19:00 Farewell dinner for workshop, welcome dinner for symposium: Hotel Schimmelpenninck Huys

university of groningen CogniGron POST DIGITAL

The 2nd year POST-DIGITAL workshop was announced on the project website. The website provided information about the programme and the venue of the event. As the 2nd year POST-DIGITAL workshop was a closed project event, the communication was mainly realised via e-mails. The registration to the event was managed through a registration form provided by the organiser Prof. Herbert Jaeger from University of Groningen.


Post-Digital Workshop (March 22 & 23) and "Scaling..." Symposium (March 24) registration

The Workshop and the Symposium are loosely coupled but essentially independent events. This registration form is for anybody who wants to attend only the workshop, or only the symposium, or both - and as far as the symposium is concerned, online or on-site. We use the information for capacity planning. The workshop and symposium are free of participation fees. Both events will be on-site, in-person. In addition, the symposium presentations will be streamed on the internet (not interactive). Registered (with this form) participants will receive more information by email.

postdigitalh2020@gmail.com Switch account

* Required

Email *

Your email

given and family name *

Your answer

Affiliation *

Your answer

*Figure 1 Registration form for the 2nd year POST-DIGITAL workshop and the mini-symposium in Groningen*


*Figure 2 The 2nd year POST-DIGITAL workshop on the project website*

## 1.2 FOCUS THEME SUGGESTIONS

In order to initiate the discussion some topics and questions were given to the participants in advance:

1. Formal theory basis

- look at the power and structure of theory in digital computing
- neuroscience doesn't give us blueprints
- what background maths? (symbolic/logic, probabilistic, dynamical systems…)
- is there hope for a unified theory basis, or is non-digital computing necessarily eclectic(maybe the brain is?)
- where do you miss formal theory in your work?

2. Applications

- Recall the kinds of applications that are currently advertised for non-digital comp
- If non-digital solutions are somehow brainlike – are they then non-programmable (butneed training or even evolutionary optimization), reproducible, understandable, predictable? (brains aren't)
- What would be user experiences / interfaces for non-digital comp systems?

- Do we need a new understanding of “computing”?
- How would we program (or train) neuromorphic computers?
- Do we need a new understanding of “programming”, or do methods of programmingalready exist that can be used for neuromorphic devices?
- Weird new revolutionary crazy use-cases?
- Is energy efficiency the only and best selling point? And is energy efficiency actually adefendable super-claim?
- Embedding non-digital in the digital world – which tasks could be best done by which sortof system?

3. Scaling up, scaling down

- The inescapable price to pay for low energy: super-small devices, noise, device mismatch,aging
- Do we have ideas for coping with the above? Or do we just happily ignore the real hardproblems still?
- 3D needed / possible?
- Scaling up to complex hardware systems and complex tasks: beyond reservoir computing,memristor hysteresis, and STDP
- What can / must we learn from cognitive science and digital computing?
- Neural Turing machines?

4. The challenge of interdisciplinarity

- Collecting a wishlist for educational support / topics
- What infrastructure would you wish? (seminars, website with tutorial materials, a Wiki,lab rotations)
- What disciplines need to contribute what?
- What would be your idea of an ideal curriculum for a Master program “non-digitialcomputing”?
- Do you think such a study program would be attractive and sustainable?

5. Is taking “inspiration from the brain” the best idea?

- Collect non-brain-inspired approaches to non-digital comp (distribute literature pointersbefore workshop)
- What are the (huge?) problems of trying to mimic brains?
- Is it only a far-fetched metaphor, good for selling mostly?
- Is *your* work/project substantially brain-inspired? What do you actually know about computational neuroscience?
- What other natural or technological or societal systems could be called “computing”?

6. Digital companionship

- How will neuromorphic work together with digital computers?

- Would we even want to have neuromorphic chips *without* digital controllers/interfaces/memory?
- Is there anything that can be done only with neuromorphic-digital co-processors, thatcannot be done by either one alone?

7. To spike or not to spike

- What is the advantage of spiking neurons over rate-based models?
- Is the energy efficiency the best argument for spikes?
- Are SNNs tools for (computational) neuroscience research or can they providecompetitive technological applications?
- Is the event-based processing (as in dynamic vision sensors) a key advantage? Or can rate-based models do the same?
- other promising event-based paradigms besides using spikes?

## 1.3 POST-DIGITAL PARTICIPATION

All POST-DIGITAL ESRs took part in the 2nd POST-DIGITAL workshop in person. Although they have regular bi-weekly meetings online and have been on different face-to-face project-wide events, the 2nd year POST-DIGITAL workshop in connection with the mini-symposium presented an amazing opportunity for discussions and close collaboration with POST-DIGITAL colleagues and supervisors and with external prominent researchers.

The following POST-DIGITAL supervisors took part in the event in person:

Sergei K. Turitsyn (coordinator, Aston), Serge MASSAR (deputy coordinator, ULB), Herbert Jaeger (Groningen), Alfredo de Rossi (Thales), Peter Bienstman (IMEC), Daniel Brunner (UBFC), Miguel C. Soriano (CSIC).

*Figure 3 Impressions from the 2nd year POST-DIGITAL workshop in Groningen*