

Institut de la Vision
Université Paris Sorbonne
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Adrien Chopin

Ph.D in Psychology
French Nationality

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Research

Interests

Stereoscopic vision, 3D vision, aging, amblyopia, stereo-recovery, perceptual learning, stereoblindness, learning, action video games, screens, falls, virtual reality, fMRI, binocular vision and rivalry

Approaches

Psychophysics, fMRI (MVPA / pRF), clinical pathology, eyetracking, video game / virtual reality training, remediation, development in newborns, reviews, best-evidence synthesis.

Academic positions

Université Paris Sorbonne (France)
Sep 2019 - now

Postdoctoral position under a ANR-Essilor-SNCF grant in Angelo Arleo's team

Université de Genève (Switzerland)
Oct 2017 – Aug 2019

Research and Teaching Fellow (Maitre-Assistant) under Daphne Bavelier's chair



- Reviewed the literature and showed that 20h of training are needed to observe perceptual gains in gaming
- Reviewed the literature on clinical stereotests and estimated at 7% the stereoblindness prevalence
- Investigated learning-to-learn framework in a large-scale pre-registered video game intervention and found increased learning speed in action video gaming
- Investigated the importance of stereo-vision for driving in a VR environment while driving a real bike
- Investigating stereo-recovery through custom-made games in a VR environment
- Developed a new stereoblindness test, in test

University of California, Berkeley (USA)
June 2016 – Sep 2017

Postdoctoral position under a NEI grant

- Investigated pRF retinotopy in anisometric amblyopes
- Investigated cortical plasticity (with fMRI) during stereo-recovery of amblyopic patients and neural correlates of stereoblindness
- Investigated the phenomenon of amblyopic rivalry

École Normale Supérieure, Paris (France)
CNRS, Paris (France)
Mar 2015 – Feb 2016

Postdoctoral position under a EU Marie Curie grant, IOF, with Pascal Mamassian

- Demonstrated stereopsis recovery for totally stereoblind amblyopic patients
- Developed a complete and modular pRF pipeline for

University of California, Berkeley (USA)
CNRS & Paris Descartes, Paris (France)
Mar 2014 – Feb 2015

processing fMRI data

Postdoctoral position under a EU Marie Curie grant, IOF, with Dennis Levi and Michael Silver

- *Demonstrated speech audio-visual integration in newborns*
- *Demonstrated binocular non-stereoscopic cues in clinical stereotests*

Université de Genève (Switzerland)
Dec 2012 - Aout 2013
Dec 2013 – Jan 2014

Postdoctoral position with Daphne Bavelier in collaboration with Dennis Levi and David Knill

- *Showed that the stereoscopic system computes relative disparities from absolute disparities*
- *Discovered dressmakers' high stereo-abilities*

University of Oxford, Oxford (UK)
Sep – Nov 2012

Visiting scholar in Christopher Summerfield's lab

- *Failed to replicate predictive adaptation in face rivalry*

CNRS & Paris Descartes, Paris (France)
Feb – June 2012

Postdoctoral position with Pascal Mamassian

- *Tested predictions of predictive adaptation framework*

Vanderbilt University, Nashville (USA)
Dec 2011 – Jan 2012
Sep - Dec 2010

Visiting Research Fellow with Randolph Blake

- *Showed that stereopsis and rivalry rely on illusory rather than real orientations whenever illusions happen*
- *Found an absence of transfer of adaptation in the bistability of ambiguous stimuli*
- *Investigated a new neural model of binocular rivalry*

University of St. Andrews, Scotland (UK)
Aug 2007

Internship with Julie Harris

- *Showed an absence of role for cyclovergence and horopter tilt in mysterious depth biases depth*

Education

Université Paris Descartes, Paris (France)
CNRS, Paris (France)
2008-2011
Defense date: 2011 Nov 28

Ph.D in Psychology with Pascal Mamassian

- Created the predictive adaptation framework
- Demonstrated implicit and probabilistic computations in human visual ambiguous perception (effect of usefulness)
- Showed that bistable preferences in perception could be created by these probabilistic computations

Highest academic distinction:
Très honorable avec les félicitations du Jury à l'unanimité.

École Normale Supérieure, Paris (France)
Université Paris Descartes, Paris (France)
EHESS, Paris (France)
2006-2008
Ranked #1, graduated summa cum laude

Master (equivalent to M.S.) in **Cognitive Sciences**, called Cogmaster

Thesis : investigated psychophysics of human binocular rivalry, demonstrating effects of usefulness

Université Paris Descartes, Paris (France)
2003-2006
Graduated magna cum laude

Licence (equivalent to B.S.) in **Psychology**

The French degree involves a detailed knowledge of clinical psychopathologies.

Université Paris Diderot, Paris (France)
2002-2003

Non-degree medical studies in Medecine school

Publications in international peer-reviewed journals

[5y-IF is the Impact Factor at 5 years]

- Chopin, A.**, Bediou, B. & Bavelier, D. (2019). Altering perception: the case of action video gaming. *Curr. Opin. Psychol.* **29**, 168–173 (2019). [Citescore 2017: 3.18]
- Chopin, A.**, Chan, S. W., Guellai, B., Bavelier, D., & Levi, D. M. (2019). Binocular non-stereoscopic cues can deceive clinical tests of stereopsis. *Scientific Reports.* **9**, 5789. [IF 2016 ISI: 4.3]
- Chopin, A.**, Bavelier, D., & Levi, D. M. (2019). The prevalence and diagnosis of ‘stereoblindness’ in adults less than 60 years of age: a best evidence synthesis. *Ophthalmic and Physiological Optics*, **39**(2), 66–85. <https://doi.org/10.1111/opo.12607> [IF 2017 ISI: 2.3]
- Chopin, A.**, Levi, D., Knill, D., & Bavelier, D. (2017) Dressmakers show enhanced stereoscopic vision. *Scientific Reports.* **7**:3435. Doi: 10.1038/s41598-017-03425-1 [IF 2015 6.75 – Altmetrics – currently 716th/265,000 articles of same age, for online attention]
- Chopin, A.**, Levi, D., Knill, D., & Bavelier, D. (2016). The absolute disparity anomaly and the mechanism of relative disparities. *Journal of Vision*, **16**(8), 2. [5y-IF 2015: 2.5]
- Guellai, B., Streri, A., **Chopin, A.**, Rider, D., & Kitamura, C. (2016). Newborns’ Sensitivity to the Visual Aspects of Infant-Directed Speech: Evidence From Point-Line Displays of Talking Faces. *Journal of Experimental Psychology: Human Perception and Performance*. DOI: 10.1037/xhp0000208 [5y-IF 2015: 2.85]
- Chopin, A.**, Mamassian, P. (2013) Response: Genuine long-term positive aftereffects. *Current Biology*, **23**(10): R439. [5y-IF 2014: 10.1]
- Chopin, A.**, Mamassian, P., & Blake, R. (2012). Stereopsis and rivalry are based on perceived rather than physical orientations. *Vision Research*, **63**: 63-68. [5y-IF 2014: 2.5]
- Harris, J. M., **Chopin, A.**, Zeiner, K. M., & Hibbard, P. B. (2012). Perception of relative depth interval: systematic biases in perceived depth. *The Quarterly Journal of Experimental Psychology*, **65**(1), 73-91. doi:10.1080/17470218.2011.589520. [IF 2014: 2.2]
- Chopin, A.**, & Mamassian, P. (2012). Predictive properties of adaptation. *Current Biology*, **22**(7): 622-626. doi:10.1016/j.cub.2012.02.021. [5y-IF 2014: 10.1]
- Chopin, A.**, & Mamassian, P. (2011). Usefulness Influences Visual Appearance in Motion Transparency Depth Rivalry. *Journal of Vision*, **11**(7). doi:10.1167/11.7.18. [5y-IF 2015: 2.5]
- Chopin, A.**, & Mamassian, P. (2010). Task usefulness affects perception of rivalrous images. *Psychological Science*, **21**(12): 1886-93. [5y-IF 2014: 6.2]

Publications in national peer-reviewed journals

- Esseily, R., Guellai, B., **Chopin, A.**, Somogyi, E. (2017) L’écran est-il bon ou mauvais pour le jeune enfant? *Spirale*, **3**(83): 28-40. doi: 10.3917/spi.083.0028

Proceedings and conferences

1. **Chopin A.**, Bavelier D., Levi D. (2019). The prevalence and diagnosis of stereoblindness: A best evidence synthesis. Poster presented at the Vision Sciences Society, St Pete's Beach, Florida, USA. [Poster VSS]
2. Shibata K., **Chopin A.**, Zhang R & Bavelier D. (2018) Learning to Learn: A generalised route to learning; Talk presented at UNIGE Neuroscience Masters' Day; Campus Biotech, Geneva Switzerland.
3. Shibata K., **Chopin A.**, Zhang R., Todeschini J., Martins M., Poma P., Denkinger S., Lu Z.L., Jaeggi S., Buschkuhl M., Green C.S. & Bavelier D. (2018) Method to study learning generalisation through training; Poster presented at UNIGE Neuroscience Masters' Day; Campus Biotech, Geneva Switzerland.
4. McDermott, K. C., **Chopin, A.**, Ptukha, A., & Mamassian, P. (2015). History effects in perception after manipulating the statistics of the environment. *Journal of Vision*, 15(12):392. doi: 10.1167/15.12.392. [Poster VSS]
5. **Chopin, A.**, Knill, D. C., Levi, D. M., & Bavelier, D. (2014). Stereoscopic depth from absolute and relative disparities. *Journal of Vision*, 14 (10), 969. doi:10.1167/14.10.969 [Poster VSS]
6. Mamassian, P., & **Chopin, A.** (2012). Long-term recalibration of orientation perception. *Perception*, 41, supplement: 42. [Talk ECVF]
7. **Chopin, A.**, Mamassian, P., & Blake, R., (2011). Transition between stereopsis and binocular rivalry is based on perceived, rather than physical, orientation. *Journal of Vision*, 11(11):301. [Poster VSS]
8. **Chopin, A.**, Capps, M., & Mamassian, P. (2010). Expectation from temporal sequences influences binocular rivalry [Abstract]. *Journal of Vision*, 10(7):347. [Poster VSS]
9. **Chopin, A.**, & Mamassian, P. (2009). Task demands can affect binocular rivalry dynamics [Abstract]. *Journal of Vision*, 9(8):299, 299a. [Poster VSS]
10. Harris, J., **Chopin, A.**, & Zeiner, K. (2008). Individual differences in depth perception: are biases correlated with eye position? [Abstract]. *Journal of Vision*, 8(6):93, 93a. [Poster VSS]

Academic talks

- 2019 – Geneva Amblyopia Meeting (Geneva). *How to measure stereoblindness and stereovision accurately in rehabilitation protocols?*
- 2017 - Invited talk – Angelo Arleo – Institut de la Vision (Paris). *Bringing completely stereoblind amblyopic patients to stereo-recovery.*
- 2017 - Invited talk – Austin Roorda – Oxyopia Seminar, School of Optometry, UC Berkeley (CA). *Bringing completely stereoblind amblyopes to stereo-recovery.*
- 2017 - Invited talk – Zoe Kourtzy & John Mollon – Rank Prize Funds Symposium on Learning to See: From Retinal to Brain Computation – Grasmere (UK). *Recovery of stereopsis in completely stereoblind amblyopes.*
- 2016 - Invited talk – Mark Wexler – LPP, Paris (France). *The mechanism of relative disparity.*
- 2016 - Invited talk – Carole Peyrin – LPNC, Grenoble (France). *The mechanism of relative disparity.*
- 2015 – Invited talk – Guillaume Masson / Frederic Chavanne – INT, Marseille (France). *The absolute disparity anomaly and the mechanism of relative disparities.*
- 2015 – Invited seminar – Simon Thorpe / Yves Trotter – Cerco, Toulouse (France). *The absolute disparity anomaly and the mechanism of relative disparities.*

- 2015 – Invited talk – Martin Banks, University of California, Berkeley (USA). *Absolute and relative disparities*.
- 2010 - Annual meeting of the doctoral school 261, hosted in Paris (France). *L'utilité d'un percept influence la bistabilité dans la transparence de mouvement*.
- 2009 - Annual national meeting of the French research in vision, the GDR Vision hosted in Toulouse (France). *Percept usefulness influences bistability in motion transparency*.
- 2008 - National workshop on perceptual bistability hosted in Paris, Ecole Normale Supérieure (France). *Expected utility in binocular rivalry*.

Grants, awards and competitions

- 2019-2023: co-leader of a work-package in the industrial grant Silversight II (Angelo Arleo, France)
- 2019: named on a workshop grant from the FNS (\$12800, with Daphné Bavelier, Switzerland).
- 2016: Qualification to the functions of the academic position of “*Maître de Conférence*”; national competition, 2016-2020, 69th section: Neurosciences.
- 2013-2015: EU Marie-Curie grant (IOF – Career development) for two year funding in University of California, Berkeley (USA) and Ecole Normale Supérieure (Paris, France), \$250,000.
- 2012: Qualification to the functions of the academic position of “*Maître de Conférence*”; national competition, 2012-2016, 16th section: Psychology.
- 2012: *Prix de thèse*, awarded once a year for the best Ph.D thesis in the Cognitive Science, Psychology, Neurosciences and Computer Science fields of the Université Paris Descartes.
- 2008-2011: Ph.D grant from the French Research Ministry (3-year funding – 85,000\$)
- 2008-2011: Teaching grant from the Université Paris Descartes (for 3-year – 15,000\$)
- 2010: Doctoral travel grant from the Université Paris Descartes. Travelled to Randolph Blake Lab, Vanderbilt University, Nashville, USA for three months of research on binocular rivalry.

Collaborations

Active collaboration groups:

1. Importance of stereopsis in driving
Anna-Flavia Di Natale, Università degli studi di Milano-Bicocca (Italy)
Daphné Bavelier, Université de Genève (Switzerland)
Emmanuela Bricolo, Università degli studi di Milano-Bicocca (Italy)
2. Dynamics of suppression in amblyopia
Robert Hess, McGill University, Montreal (Canada)
Jacob Sheynin, McGill University, Montreal (Canada)
Dennis Levi, University of California, Berkeley (USA)
3. Amblyopic rivalry
Claudia Lunghi, Pisa University, Pisa (Italy)
Concetta Morrone, Pisa University, Pisa (Italy)
Dennis Levi, University of California, Berkeley (USA)
4. Sound-structure categorization in newborns and adults
Bahia Guellai, Université Paris Ouest Nanterre La Défense, Nanterre (France)
5. Virtual reality gaming to trigger stereopsis recovery
Daphné Bavelier, Université de Genève (Switzerland)
Dennis Levi, University of California, Berkeley (USA)
Ben Backus, SUNY, Vivid Vision (USA)

- Vivid Vision (company, USA)
 Lauren Spano, University of California, Berkeley (USA)
6. Neural correlates of stereopsis recovery
 Michael Silver, University of California, Berkeley (USA)
 Jian Ding, University of California, Berkeley (USA)
 Eunice Yang, University of California, Berkeley (USA)
 Dennis Levi, University of California, Berkeley (USA)

Former collaboration groups:

7. Rana Esseily, Université Paris Ouest Nanterre La Défense, Nanterre (France)
 Bahia Guellai, Université Paris Ouest Nanterre La Défense, Nanterre (France)
 Eszter Somogyi, Université Paris Descartes, Paris (France)
8. Kyle McDermott, University of California, Davis (USA)
 Pascal Mamassian, Université Paris Descartes & CNRS (France)
9. Arlette Streri, Université Paris Descartes, Paris (France)
 Bahia Guellai, Université Paris Ouest Nanterre La Défense, Nanterre (France)
10. Daphné Bavelier, Université de Genève (Switzerland)
 Dennis Levi, University of California, Berkeley (USA)
 David Knill, University of Rochester (USA)
11. Randolph Blake, Vanderbilt University (TN, USA)
 Jan Brascamp, Utrecht University (the Netherlands)
12. Christopher Summerfield, University of Oxford (UK)
13. Julie Harris, University of St. Andrews (UK)
14. Raymond van Ee, Utrecht University (the Netherlands)

Teaching

2019: class to teachers in continuing education (3h: *The effect of screens on intellectual development*) - DIP-SEM, Genève, Switzerland.

2008-2011: Teaching assistant ("Monitorat" at CIES Paris Sorbonne) in Psychology.

Year	UE	Hours	Audience
2011	Differential Psychology	26h	B.S. students
2011	Experimental Psychology	52h	B.S. students
2010	Experimental Psychology	52h	B.S. students
2009	Experimental Psychology	52h	B.S. students
2009	Differential Psychology	26h	B.S. students

Total: 211h

Mentoring: mentoring 1 Ph.D. student, 12 graduate students and 11 undergraduate students, including a successful honor thesis.

Qualification for the French position *Maître de Conférence*: 16th section (2012: Psychology) and 69th section (2016: Neurosciences)

Service

2019-06: co-organized the 2019 Geneva Amblyopia Meeting, an international 2-days workshop gathering the leaders of visual interventions in amblyopia, with a grant from the Swiss FNS.

2019-03: co-organized the Festival of Education of Switzerland, in Geneva (<https://printemps-education.ch/festival-education/>).

2015-2017: created an fMRI-analysis pipeline (Pipeline_JAS) - a set of matlab automated modules for pre-processing, segmentation of fMRI data in mrVista/Freesurfer/FSL, pRF retinotopy and visualization. Shared on Github (https://github.com/Stereo-Boy/Pipeline_AS) and wrote an extensive wiki documentation for it.

2014-2016: Organized the lab system for enrolling and screening amblyopic patients with the eye clinic.

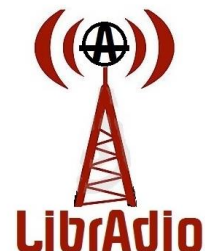
2010 – 2011: elected member at the Doctoral Council of Paris Descartes University.

2010: Organized of the LPP's Perception Journal Club.

2007-2008: Founded a student seminar in the Cogmaster.

Reviewing: peer-reviewing for the following scientific journals: Optometry and Vision Science, Plos Computational Biology, Current Biology, Nature Group: Scientific Reports, Journal of Vision, Vision Research, Frontiers in Human Neuroscience, The International Journal for the Psychology of Religion

Media presence & General public dissemination





- Dec 2018: Interviewed for “Ca m’intéresse” (French monthly magazine 200.000 readers/month).
- Sept 2018: Interviewed for Libraradio, broadcasted on Frequence Banane (local Swiss-French radio).
- May 29 2018 and June 6: Invited talk at preview showings of the documentary “Le Cerveau des Enfants” about how we can use neuroscience discoveries to help children learn and grow cognitive skills (Cinelux, Geneva) – broad audience.
- June 2017: Our study about dressmaker’s enhanced stereovision received world coverage. Interviewed for BBC (World Service *Healthcheck* – 260 millions listeners/month), CBS News Radio (*Science Today* - 260 millions listeners/month), KBCS news radio, NPR (*Health Shots* – 84 millions listeners/month), BYU radio (*Top of the Mind with Julie Rose*), the AOP (*Optometry Today*), and *Inside Science*. From Altmetrics, >58 news outlets reported our study.
- Jan 2017: Interviewed for PC Gamer (22.000 readers a month) about visual perception in video games. *How many frames per second can the human eye really see? Alex Wiltshire*
- October 2016: Interviewed for the *Berkeley Optometry Magazine* about the efficiency of stereopsis recovery and one of my recovered patient. *Discovering the World’s Depth Later in Life. Gordy Slack*
- May 2016: published two articles about open-access for the biology website BiteSize Bio (200.000 readers a month). *How to Access All Science for Free? / Five Truths About Science Publishing or Why All Science Should be Free. Adrien Chopin*
- Apr 2016: published an article on the cognitive impact of TV and screens on very young children, including the mechanism, for Coginnov (non-profit), illustrated by Fiamma Luzzati. *Les écrans en quelques maux. Adrien Chopin, Bahia Guellai and Nawal Abboub.*
- Mar 2016: Interviewed for the French magazine “La Recherche” (65.000 readers a month), on stereoscopic vision in insects and the reason why it tells us something interesting. *La mante religieuse, nouveau modèle d’étude de la vision 3D? Laurence Dennis.*
- 2016: I created or completed the following entries on Wikipedia (under the name Adrien16): Fusion binoculaire (FR – 100%); Rivalité binoculaire (FR – 98%); Amblyopie (FR - 23% - 64.000 readers/year); Binocular rivalry (EN - 10% -14.000 readers/year); Amblyopia (EN - 6.2% - 280.000 readers/year); Gustav Fechner (FR - 4%); Sciences cognitives (FR- 3%); Diplopie (FR - 2%)
- Sep 2013: Interviewed for the Swiss radio RTS, la Première (channel), CQFD, on treating amblyopia and stereoblindness with dichoptic action video games. *Les bienfaits des jeux vidéo pour la santé. Bastien Confino.*
- Mar-May 2011: Consulting for a diffusion project about Cognitive Sciences targeted to elementary school with the organization “la Main à la Pâte” (coordination: Elena Pasquinelli) about the impact of screens on children cognition
- Mar 2009-2010-2011: Co-organized a scientific exhibition (surface 50m²), on 3 consecutive years, hosted at the French Forum of Cognitive Sciences, Paris, about face perception, self-perception, neuro-imagery, change blindness, split-brain and language development. The framework was a DCST project that we wrote (financed by the CIES Sorbonne, Jussieu, Nanterre and Créteil), named “Les Sciences Cognitives Expliquées”.

Feb 2010: Series of speeches and demonstrations for the non-profit organization “Science Académie” about Brain, Philosophy and Damages, to a public of high-school students in Paris. “Poverty of vision revealed by change blindness and inattention blindness”.

Nov 2008: Co-organized a full-day exhibition at the Paris Science Festival for the RISC and Cognivence (about bistability).

Apr 2008: Co-organized the 7th French Forum of Cognitive Sciences in Paris.

Nov 2007: Series of speeches and demonstrations on a full day for the 16th national Science Festival in Paris, to a broad audience public. “What does perceptual bistability teach us?”

May 2007 and 2006: Series of demonstrations on a full day for the 5th and the 6th French Forum of Cognitive Sciences in Paris to a broad audience public. “What do illusions tell us?”

2007-2010: Elected member of the administration council of the student organization Cognivence (Association of the Students in Cognitive Sciences from Ile de France).

Professional skills

Methods: Psychophysics, computational models, virtual reality, fMRI, pathology, eyetracking, reviews.

Statistical Analysis: inferential statistics (frequentist and Bayesian), linear and non-linear models, parametric and non-parametric tests, fMRI permutation tests / cross-validation, bootstrap. Statistica/matlab/SPM.

Clinical patients: amblyopic patient management (strabismic and anisometropic); basic optometry procedures; clinical recruitment schemes; ethics

Certified trainings and Ethics

Safety training course and standard operating procedures (2014-2017) and user training course (2015-2017) - Li Ka Shing Brain Imaging Center (UCB, USA).

Group 1 Biomedical research investigators and key personnel – score 92% (CITI program 2014)

Sexual Violence and Sexual Harassment Prevention Training for Staff – score 100% (UCB e-course 2015) and refresher (2017)

Ethical Values and Conduct (UCB e-course 2015)

Cyber Security Awareness (UCB e-course 2015) and refresher (2017)

Conflict of Interest for Researchers Briefing (COIR UCB e-course 2017)

Technical apparatus: expertise in MRI scanning (operator for 3T Siemens Trio scanner), virtual reality sets (fMRI-compatible 3D goggles VisualSystem, Oculus, Vive), stereo-optical devices (stereoscopes, 3D glasses, parallax barrier), eye tracking (Eyelink II and Arrington VisualSystem eyetracker with Viewpoint), photometry (photometers), clinical stereo-tests (most of them), acuity tests (Sloan and Bailey Lovie charts), visual field tests (Goldmann perimeter), measure of refractive errors (autorefractor, subjective refraction)

MRI data analysis: MVPA (TdT), pRF and retinotopy (mrVista, FSL, Freesurfer, itkGray), statistical analysis (SPM).

Languages: French (native), English (fluent), German (correct understanding)

Programming: Matlab & PsychToolBox (advanced), Python (beginner)

Web design: Blogging, HTML/CSS/Javascript (Front-End), PHP/SQL (Back-End server and database), Weebly/wordpress (CMS).

Lab managing: managing a team of 8 simultaneous research assistants; lab wiki managing

Group work: Leading collaboration in a team of 4 international collaborators on a project with the relevant collaborative tools (Asana, Github, Google docs)

Personal commitment & Activism

I am strongly committed and active in the following causes:

- ❖ Universal access to science (as provider of the webpage <https://tinyurl.com/y62oof55>)
- ❖ Ecology and efficient altruism (as founder of the collective Verts-Luisants - <http://vertsluisants.fr> - promoting efficient altruistic donations, ecology and zero waste)
- ❖ Education (as website manager for Le Printemps de l'Éducation – Suisse - <https://printemps-education.ch/> - a Swiss non-profit for promoting innovative, alternative or efficient education)
- ❖ Zero-waste (as creator of the Facebook Zero-Waste challenge - <https://tinyurl.com/y5urg8o3>)