Project title: Primate Cognition – Information integration in a complex social world

Project number: W45/2019

Executive Summary

The ScienceCampus Primate Cognition served as a local research hub to foster scientific collaboration and to support novel concepts and methods for research on the social behavior and cognition of human and nonhuman primates. The start of the 2nd funding period was significantly affected by the COVID-19 pandemic, leading to an extended run-time of five years. Despite this disruption, all major milestones proposed in the proposal have been achieved: the research infrastructure has been significantly expanded, interdisciplinary collaborations have become a common theme throughout the network, and a new research building (€37m) is currently under construction. In addition, a DFG-funded Collaborative Research Center and a Research Training Group will provide funding to continue our research. The ScienceCampus was a key contributor and facilitator for these initiatives and laid the groundwork for the establishment of the Göttingen Campus Core Research Area *Foundations of Cognitive Processes*. Led by a group of ScienceCampus members, this Research Area will be transformed into a Campus Research Alliance *Cognition, Brain and Behavior* to further shape our research and teaching on the Göttingen Campus. The Audacity Funds were a key instrument in the 2nd funding period. They supported bottom-up proposals with a focus on i) kick-starting new initiatives and ii) conceptual, technical, or analytical approaches with long-term potential, including various machine-learning initiatives. Concerning analytics, the ScienceCampus hired one of the leading experts for statistical modelling of behavior. In addition to his research contributions, he established a statistical training program for early-career researchers that gained international recognition, attracting scholars from the Americas to Göttingen. Taken together, the 2nd funding period allowed us to consolidate our role as a key player on the Göttingen Campus.

1. Achievement of objectives and milestones

As proposed, we extended our investigations of individual cognition and behavior to dyadic interactions and multi-player settings in complex social groups of different social organizations in two closely intertwined research areas. Below, we comment on all milestones that have been proposed:

- **Establishment of a DFG Collaborative Research Centre (SFB)**: The SFB 1528 *Cognition of Interaction* started in January 2022. Led by Alexander Gail (Sensorimotor Neuroscience), 17 ScienceCampus members are among the group of 22 PIs. We are currently preparing a proposal for a second funding period.
- **Establishment of a DFG Research Training Group**: Funding was obtained for the RTG 2906 *Curiosity*, which started in September 2024. Led by Nivedita Mani (Psychology of Language), 11 of the 13 PIs are members of the ScienceCampus.
- **Establishment of a new experimental research building for psychology**. Led by Anne Schacht (Department for Cognition, Emotion and Behavior), the team includes eight ScienceCampus members among the ten PIs. Currently under construction, the building will become fully operational in 2026. Two MEG systems will be purchased; a Coordinator and a Lab Manager have already been hired.
- **Establishment of internal funding lines:** All proposed funding lines were established (see chapters 2 and 3 for details)
- **Hiring of a biostatistician and start of a structured statistical training program**: Roger Mundry was recruited from the University of Vienna. His workshop program started in early summer 2021.

- **Establishment of "Equal Opportunities Support Pool":** The pool was established in collaboration with the Gender Consulting Office at the University Medical Center and offered free workshops and coaching as well as individually tailored support measures.
- **Initiation of a new Movie Night series with a local art house cinema:** The *Science Movie Nights – Of natural and artificial intelligences* series was held from February to April 2024.
- **Primate Cognition Symposium at the Annual Meeting of the German Neuroscience Society**: This event had to be postponed to 2023 due to the COVID-19 pandemic. Guest speakers were Daniel Huber (Geneva) and Dora Angelaki (NY University)
- **Completion of new animal housing and testing facilities at the DPZ**: The construction was finished in late 2021, and the animals were transferred in 2022.
- **Think tank workshops:** A workshop on *Social Curiosity* was held in 2022 to support plans for the RTG *Curiosity*. In 2024, we organized the *Primate Cognitive Neuroscience Summer School.*
- **Presentations at the Night of Science:** The ScienceCampus contributed to the Night of Science in 2022 and 2025 as well as the IdeenExpo Hannover in 2024.
- **Establishment of a second Dyadic Interaction Platform (DIP):** We vastly expanded the availability of DIPs. We operate now one DIP for rhesus macaques, two DIPs for human adults, and one for young children. Another DIP for Guinea baboons is currently under construction at our new collaboration partner, the Nürnberg Zoo.
- **Workshop with the Data Science Institute:** The idea for this workshop became obsolete when machine learning became an integral component in various Audacity Grant projects.
- **Closing Conference of the ScienceCampus and publication of a special issue on research topics of the ScienceCampus:** We held a closing event with Asifa Majid (Oxford) in February 2025 and are currently organizing the *First Göttingen Cognition Forum: Curiosity & Interaction*, to be held Oct. 13-15, 2025.

Due to funding cuts imposed by the Leibniz Association, we had to modify our spending plan considerably. We provided Audacity grants as proposed, but significantly reduced all mobility-related activities. The workshop program could be maintained at lower costs due to more in-house offers. We also reduced administrative salaries.

2. Activities and obstacles

The core research activities were conducted as part of the 31 Audacity grants. We gave preference to either a) proof-of-concept studies to prepare new initiatives, or b) projects aimed at developing novel methods and tools, in particular, more realistic testing conditions or novel analytical approaches.

Broadly, our research tackled the following questions: (i) how do individuals process others' body and motion cues during social foraging; (ii) which cues and subjects receive their attention; (iii) how do subjects assess others' competences and selectively interact with competent partners; (iv) how do individuals regulate emotion expression and processing in social interactions; and (v) how do individuals weigh and act on advice and feedback.

We are in the middle of a shift in our field to more complex and realistic test conditions for a better understanding of social cognition and its underlying behavioral, psychological, and neuronal mechanisms. Towards this goal, we had previously developed the Dyadic Interaction Platform (DIP). This transparent, dual-sided touchscreen allows two partners to play competitive or cooperative interactive games while seeing each other's gestures, choices, and facial expressions. We have now upgraded the DIP for better screen transparency, added head-free real-time eye-tracking capabilities, created mobile versions, adapted a DIP for use with children, and are currently establishing a DIP for tests with baboons in a zoo setting. To go beyond dyadic interactions, we have established an "Exploration Room," a large, customizable room in which one or more rhesus monkeys can freely explore and interact with a range of different feeders, objects, and touchscreens; we can simultaneously record their

brain activity with permanently implanted electrodes. Up to 30 cameras allow us to automatically analyze behavior and movement patterns using machine learning (ML) algorithms.
Three projects developed tools for multimodal cognitive testing. The new automated facilities allow testing for auditory learning, including tests conducted during MRI scanning. We are also exploring optogenetic approaches to better understand the neural mechanisms of auditory cognition. Audacity Fund projects developed automatic feeders and camera systems for freely ranging monkeys at our field sites. For human studies, we established mobile apps for experience sampling to assess emotion regulation and psychological well-being in real-life contexts.
A thorough understanding of social interactions and social predispositions has tremendous potential for diagnostics, treatments, and interventions. For this purpose, we established the *Phenomobil*, a van-based infant lab to visit parents at home to study the early ontogeny of social interactions. These home visits increase the test–retest rate in longitudinal studies. By comparing infants with higher and lower risk for an autism spectrum disorder (ASD) diagnosis, we aim to identify early markers for such late-detectable developmental disorders. In the van, we can characterize infant–parent interactions with high precision by recording various physiological parameters and vocalizations, identifying gaze direction, and tracking movement and reach patterns. To assess interaction patterns in adolescents and adults diagnosed with ASD in everyday-life settings, we established testing schemes with wearable eye-trackers.
To identify animal models for ASD, we explored whether questionnaire-based scoring tools from human studies could be adapted for non-human primates. Unfortunately, two independent approaches failed to identify non-human primates with unusual patterns of social behavior. Instead, results supported approaches that allow automated recordings of rich behavioral repertoires. Towards this goal, another project developed ML tools to locate, identify, and track individual monkeys automatically. We are currently working on automatic behavioral analysis and gaze direction detection.
Our focus on developing new methods is paying dividends, as we now have multiple concept and method publications submitted or published, each with more than 10 ScienceCampus members as authors. Despite this progress, the COVID-19 pandemic caused significant delays, as most research activities had to be suspended for several months. After the lockdowns, we observed, for example, a reluctance of parents to visit our labs with their infants. Breakdowns in global supply chains and shortages of GPU processors caused further delays. In the last year, bureaucratic hurdles during the renewal of our animal experimentation licenses led to a temporary halt in neuroscientific studies.

3. Results and successes

Please see Table 3.1 for a complete list of publications, the vast majority of which are available as open access. We list all publications in which members used a ScienceCampus affiliation to indicate their relevance to our research agenda. After the lockdowns, we resumed our lectures and statistics workshops, initially as an online series. Since then, we have returned to an on-site event series (Tables 3.2 and 3.5).
We did not fund PhD positions directly but provided support measures for PhD students (see Chapter 4). Table 3.3. lists all PhD theses conducted by ScienceCampus members; Bachelor's and Master's theses were conducted as part of Audacity Grant projects. The effectiveness of our measures to promote collaborative activities and to support excellent research is reflected in the additional funding obtained by our members (Table 3.4). Most noteworthy are the successful applications for the SFB 1528 *Cognition of Interaction* and the RTG 2906 *Curiosity*, the establishment of the new Research Center *Human Cognition and Behavior*, and the extension of the Research Training Group 2070. Members also received an ERC Starting Grant, an ERC consolidator grant, and a Reinhard Koselleck Grant. In total, members have obtained funding of more than €82m. Of particular relevance are grants involving collaborations with data scientists and AI researchers, which we earlier identified as a specific goal for the 2nd funding period. In addition to the SFB 1528 and the RTG 2906, this includes

projects within the SFBs 1456 and 1690 and the project *Cognitively and Empathically Intelligent Collaborating Robots* with Florentin Wörgötter and Anne Schacht.
Among our outreach highlights (Movie Nights, Night of Science, IdeenExpo), the exhibition *Ich – Du – Wir* by our RTG 2070 drew particular attention. From April to November 2024, visitors to the Forum Wissen in Göttingen explored how we study social relationships in humans and primates. Showcasing the research of twelve PhD students, the exhibition attracted more than 16,000 visitors.

4. Equal opportunities, career development, and internationalization

The staff funded by the ScienceCampus was limited to a small coordination team, whose composition changed over time. All but one of the positions were filled by women, two of whom were internationals. The Audacity Grants were mostly used to hire student assistants (see Table 4), the majority of whom were female. ScienceCampus membership varied due to graduation and job changes; across the 2nd funding period, members represented nearly thirty different nations from five different continents. About 61% of all members were female, with nearly ¾ of all PhD student members being female. Local field assistants were employed at all field stations.
One third of audacity funds were headed by early career researchers (ECR), and 36% of main and co-applicants were ECRs. Women accounted for 46% of project leaders and 49% of all project partners.
As advanced analytical skills have become increasingly important for ECRs, the partner institutions jointly recruited Roger Mundry, one of the leading experts in statistical modelling (see also Chapter 7). His internationally renowned workshops attract participants from across Europe and the Americas. Securing his involvement with the ScienceCampus significantly increased our international visibility. A total of 33 conference visit grants and outgoing grants (for longer visits to international laboratories) were awarded to ECRs. Because of the pandemic, demand for these grants was lower than during the first funding period.
In support of diversity, equity, and inclusion, we partnered with the Gender Consulting Office of the University Medical Center. Our members were eligible to participate in workshops and coaching offers, with the ScienceCampus covering the fees. We also provided funding for childcare during conference visits and for participation in (international) mentoring schemes.

5. Structures and collaboration

The structures remained as outlined in the proposal. The Board of Directors consisted of Julia Fischer, Julia Ostner, Hannes Rakoczy, Stefan Treue, and Fred Wolf. An elected Steering Committee assisted the Directors in evaluating the activities and funding decisions; new committee members were elected every two years. The Scientific Advisory Board consisted of Robert Seyfarth (University of Pennsylvania), Winrich Freiwald (Rockefeller University), Gaia Scerif (Oxford University), Adrienne Fairhall (University of Washington, Seattle), and Ralph Hertwig (MPI Human Development Berlin); In autumn 2021, Hertwig resigned and was replaced by Thomas Münte (Kiel). Newly established collaborations (see Tables 5.1 and 5.2) represent individual collaborations that did not require changes to the ScienceCampus contracts.

6. Quality assurance

Good scientific practice workshops are mandatory for all PhD students in Göttingen. Several ScienceCampus members are involved in the Göttingen *Open Source & Science Initiative of Psychology* as well as international open science initiatives such as *ManyBabies*, *ManyPrimates* or the *PRIMatE Data Exchange consortium in nonhuman primate neuroimaging*.
More than three-quarters of all publications associated with the ScienceCampus are openly available, and nearly half of all publications made primary data publicly available (see Table

3.1). Preregistration is becoming increasingly common. Members of the ScienceCampus are among the proponents of *MacaqueNet*, an Open Data platform for long-term data sets of macaque field sites; we contributed to the conservation of two large datasets from the 1980s.
Some projects with non-human primates at the German Primate Center involve animal experimentation; all studies are conducted after approval by the responsible authorities. Whenever possible, experimental animals are group-housed in facilities that vastly exceed the legally mandated standards. The Primate Center employs several dedicated veterinarians to monitor the welfare of the animals and has established a special training program for caretakers.
Several of our projects aim to reduce the burden on animals and to create more naturalistic test situations. The Exploration Room, working on remote markerless tracking of animal movements, wireless recordings of neural signals, and self-serving tests for group-housed animals, all contribute to 3R and animal welfare.

7. Additional resources

The DPZ and the University jointly funded the position of our biostatistician, and he was retained beyond the run-time of the ScienceCampus; he is involved in various projects, and his workshops and counselling services are in very high demand.
Both institutional partners contribute to our field stations to support work on nonhuman primates in their natural habitats (staff and running costs). In Göttingen, the new test facility *Primate Cognition and Behavior (PriCaB)* opened in 2022; the DPZ also provided MRI scanning hours in our Imaging Center, but we used fewer resources than initially assumed. The support for animals was lower than anticipated because we stopped testing long-tailed macaques. Instead, we established a collaboration to study Guinea baboons at Nürnberg zoo, as this aligns better with our field research on the same species in Senegal. To accommodate the increasing demands for data processing, the DPZ provided a scientific IT coordinator for machine learning pipelines. We benefited greatly from the hiring of Alexander Ecker on a professorship for Neural Data Science; even though we had to calculate his contributions at lower monetary values due to co-funding for this position from other sources, he was involved in two Audacity Grant projects and is PI of the *SFB 1528*, the *RTG 2906*, and *HuCaB*. The University had originally retained Thomas Schultze-Gerlach, but he accepted a position at the University of Belfast in early 2022. Further support was provided for different psychology labs that all played major roles in our collaborative applications and at which DIPs have been established by now. Furthermore, two coordinator positions were provided to establishing *HuCaB* and the *RTG 2906 Curiosity*.

8. Outlook

Based on the ScienceCampus activities, we could establish a key research area *Foundations of Cognitive Processes* at the Göttingen Campus, which will also encompass the research buildings *HuCaB* and *PriCaB* as high-end infrastructure. The new *Primate Data Science (PRIDAS)* unit at the DPZ and the Campus Institute Data Science will continue to expand our data science agenda. We are currently finalizing plans to transform the key research area to a *Campus Alliance Cognition, Brain and Behavior*. With funding from the Ministry of Science and Culture in Lower Saxony, the Campus Alliance shall serve as the long-term representative of our local network and will expand it nationally and internationally. It will also serve as a hub for the continuous development of cutting-edge tools, a supporter for promising early career researchers, and a source of further collaborative funding initiatives. Within the Campus Alliance, we plan to merge different study programs in a unified interdisciplinary Master program *Cognition, Brain and Behavior* with a corresponding PhD program. To establish an internationally visibly brand, we plan a recurring Summer School series *Cognition, Brain and Behavior* and the bi-annual *Göttingen Cognition Forum*; the first Forum is taking place in October 2025.