Research statement

Florian Krause

I am interested in understanding the neural implementation of cognitive and affective processes at multiple levels, how their interplay influences behaviour and functioning in every-day life, and how we can in turn use new technologies to better regulate this. I address these questions using an interdisciplinary empirical approach that combines a variety of behavioural (speeded responses, eye-tracking, questionnaires, experience sampling) and physiological measures (heart rate, respiration, skin conductance, motion, pupil size), as well as neuroimaging and neuromodulation techniques (fMRI, EEG, neurofeedback). The goal of my research is to combine fundamental neurocognitive knowledge, advanced neuroimaging, and transferable mobile technology (mobile apps, wearables) to develop innovative new ways to promote and sustain optimal performance and well-being by strengthening resilience in daily life, and I aim for my research to ultimately have impact on society and to contribute to clinical as well as educational progress. To achieve this goal, I actively contribute to multiple research domains: (1) advanced research methods & technologies, (2) stress & resilience, (3) embodied & numerical cognition.

Advanced research methods & technologies

I use a large variety of different methodology in my work, ranging from behavioural and physiological measures, over real-life assessments with mobile devices and wearables, to advanced neuroimaging. Since using state-of-the art methods and technologies is crucial to my research, I aim to actively contribute to the constant improvement and development thereof.

Open Science & free methods and software

I am a strong advocate of Open Science and the development of free methods and software technologies. One of my best-known contributions in this field is probably "Expyriment" (https://www.expyriment.org; Krause & Lindemann, 2014), a major software package in experimental Psychology and Neuroscience, of which I am the creator and maintainer since over 10 years now. As an expert in software for timing-accurate computer-based experiments, I have been active in educating fellow researchers on this topic and to raise awareness for common misconceptions and pitfalls (e.g. Krause & Lindemann, 2021). In addition to that, I am constantly contributing to the Open Science ecosystem in the form of free research software (see https://floriankrause.org/open-science for an overview), as well as with conceptual ideas on how to solve outstanding problem, for instance in the domain of research data integrity (Lindemann & Krause, 2021).

Advanced (real-time) neuroimaging & neurofeedback

Not only do I strive to improve standard neuroimaging practice, with several contributions in that domain, ranging from mitigating head motion to (Krause et al., 2019) to exploring new imaging modalities (Lührs et al., 2019), I also have a strong interest in real-time neuroimaging, and especially neurofeedback. Neurofeedback is a form of endogenous neuromodulation with which an individual can be trained to self-regulate specific neural parameters. It offers several advantages over other non-invasive neuromodulation techniques, such as the ability to target more complex and multivariate neural parameters and (once learned) applicability outside of a lab-context. I am interested in how the self-regulation of brain networks by (combined) Electroencephalography (EEG) and especially real-time fMRI (rtfMRI) neurofeedback can be methodologically further advanced to be utilised as a therapeutic measure for brain disorders. My research in this domain focuses on developing innovative new paradigms and their clinical applications. For instance, I was among the first to explore the effects of graded (multi-level) neurofeedback (Krause et al., 2017), and its potential benefits for neurofeedback training of motor imagery in stroke patients (Mehler et al., 2019; Mehler et al., 2020). More recently, I was the first to implement stress-related large-scale brain network neurofeedback training as a potential new treatment modality for stress-related disorders (Krause et al., 2021).

Real-life physiology & experience sampling

Lately, I developed a strong interest in translating neuroscientific knowledge to situations outside of a lab environment and into real-life scenarios. To this end, my current research embraces experience sampling (e.g. ecological momentary assessments) and physiological data from wearable biosensors (e.g. smart watches), as well as the combination of both (Tutunji et al., 2021). I am currently combining this data with my neuroimaging work (Krause et al., in prep.) and my long-term goal is to develop more cost effective and accessible biofeedback-based mobile transfer technologies that can support successful network-neurofeedback training (Krause et al., 2021).

Stress & resilience

Stress-related disorders are one of the most threatening mental health issues of our time, with an alarming combination of both high disease burden and high global prevalence – a situation that is further fuelled by ongoing global crises, such as the COVID-19 pandemic and the war in Ukraine, as well as increasing uncertainty of future geopolitical changes and the consequences of climate change. My research in this domain aims at finding innovative new ways to promote and sustain mental health by strengthening resilience to stress in real life. To this effect, I am interested in the neuroscience of stress-related mental disorders, especially in stress-related large-scale brain network changes, and how we can integrate that knowledge with behavioural data (e.g. experience sampling) and physiology from wearable biosensor in order to translate it out of the lab and into real-life scenarios. I was involved in recent pioneering work that combines experience sampling with wearable biosensors (Tutunji et al., 2021), and I was the first to implement stress-related large-scale brain network neurofeedback training as a potential new treatment modality for stress-related disorders (Krause et al., 2021). Using both of these methodologies, I was recently able to demonstrate for the very first time that mental strategies learned from neurofeedback are not only a persistent skill, but that the application of that skill in real-life affects measures of daily-life stress (Krause et al., in prep.; see also https://floriankrause.org/NVP2022_poster.pdf). I am currently applying this new paradigm to a PTSD patient population in a multi-centre study between MaastrichtUMC+ and RadboudUMC. In the future, I would like to also extend this research to a younger population (children and adolescents), who are especially vulnerable to external factors such as trauma and stress, and where interfering with resilience training before crucial crossroads in development (i.e. around the time of onset of stress-related disorders) can be expected to have maximal effects.

Embodied & numerical cognition

I am interested in the question of how former sensorimotor experiences shape our cognition and how differences in these experiences can lead to individual traits in cognitive functions. My research in this area focuses on the neurocognitive representation of numerical magnitude and the question of whether numerical concepts are "grounded" in former sensorimotor experiences with size in everyday life. Numbers are present in every part of modern society and each day we process several thousands of them. In fact, comprehending and manipulating numerical information has become such an essential cognitive ability that having deficits in this domain makes individuals less employable, significantly reduces lifetime earnings and is even a risk factor for depression. Consequently, understanding how our brain represents and processes this information is important for educational and clinical purposes alike. In multiple studies, I was able to show that numerical information interact with non-numerical information about sensorimotor magnitudes (Krause et al., 2013, Krause et al., 2017), and that a generalizes system that represents magnitudes from different domains already exists in early childhood (2019). I was also the first to identify structural neural bases for inter-individual differences in those sensorimotor number representations (Krause et al., 2014). I believe that this work can have consequences for how we teach numerical knowledge and mathematics in schools, and this has also been recognized by experts in the education sector, as I have been approached to share my work with a broad audience of teachers at the "Panama" conference for mathematics education in the Netherlands, as well as the Dutch teachers journal "Jeugd in School en Wereld". Next steps in this research line involve investigating how we can better support numerical and mathematical abilities in children (especially those with learning deficits) by specifically reinforcing sensorimotor couplings to other daily-life magnitudes. To this effect, I have a developed a prototype of a serious game which was well received by several experts and won an award (Krause, 2017).

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Teaching statement

Florian Krause

I have always been **very interested in education innovation**, especially in how we can better and faster translate recent scientific knowledge into teaching practice, and how new technologies can bring new opportunities to do so. I have in the past been invited to speak about my ideas at the "Panama" conference for mathematics education in the Netherlands, and to write an article for the teachers journal "Jeugd in School en Wereld". I have also developed a mobile app for innovation in math education ("Magnishoot") which was well received by several experts and won an award.

This general interest in education directly translates into my academic teaching activities. I enjoy passing on knowledge to students, inspiring new generations of scientists and coaching them in their process to become independent researchers. Over the years, I have gained **experience with the supervision of students in several stages of their education (Bachelor, Master, PhD), as well as more large-scale teaching (tutorials and lectures)**. I have contributed to several courses related to the fields of Psychology and Neuroscience as a co/guest-lecturer or instructor at Radboud University ("Toegepaste Onderzoeksmethoden Brein", Bachelors in Psychology; "Neuroscience of stress-related psychopathology", Bachelor's in Biomedical Sciences; "Higher order cognition and emotion", Master's in Biomedical Sciences; "Advanced Brain-Computer Interfaces", Master's in Artificial Intelligence) as well as Maastricht University ("Academic writing", Bachelor's in Psychology). Beyond that, I have supervised over 20 students with different backgrounds (Psychology, Cognitive Neuroscience, Biomedical Sciences) one-on-one as part of their Bachelor's, Master's or PhD projects in multiple domains (numerical/embodied cognition, infant research, stress/resilience research).

I strongly believe that in addition to teaching our students a mechanistic understanding of neurocognitive processes and "hard" facts, we need to strive for equipping them with the means to "think scientifically". That is, **we need to put our students into a position where they can recognize and evaluate new problems, translate them into appropriate research questions, make the right decisions on how to best approach those methodologically and statistically in order to find meaningful answers, and efficiently communicate them with their peers as well as other stakeholders**. This includes large-scale teaching as well as practical courses targeted specifically at training these skills, but also requires more individual hands-on approaches like research internships. One thing I have come to realize since I have started teaching is that it is very important to **have the room to accommodate for individual learning trajectories**. This is, in my experience, **especially true for methodological topics**, such as programming and data analysis, where the routes of access to those topics can differ significantly between individuals, and taking the time to do so has proven very successful to me in the past.

As a proponent and advocate of **Open Science**, I find it also extremely important to educate students about best scientific practices, such as **scientific integrity, transparency and the "FAIR" principles of reproducible research**, as well as introducing them to the nowadays wonderful ecosystem of free and open tools that support and facilitate research processes. I have been actively involved in these activities by giving tutorials and workshops in experiment design/creation/implementation, programming, data processing and analysis as well as academic/scientific writing/publishing, as well as by contributing to the department more generally with support for research practices and infrastructure. Ultimately, however, I think that we should **work towards making these topics an integral part of the agenda of research master programmes**, for instance in form of a dedicated course that introduces and discusses each of the concepts of the full Open Science research process (i.e. study pre-registration, usage of preprint servers, Open Access publishing, Open Data and sharing), the contemporary tools and services that enable them (e.g. Git/DataLad, Psych-DS, BIDS, GitHub, OSF, PsyArXiv), as well as related ethical and legal matters (e.g. data privacy, copyright and licencing your work, intellectual property).

Last, but not least, I find it also important to have a **knowledge transfer** that goes beyond a student population, and allows a **dialogue with other and broader parts of society**. To this effect I am trying to actively participate in dissemination activities, such as publishing news articles about my research on university/institute websites as well as social media, writing articles and blog posts for various online platforms, as well as organizing and participating in hackathons and workshops that bring together academics with other societal partners from industry and education.