NeuroIS SOCIETY

The NeuroIS Society Magazine
2022 | No. 1

COVER STORY

Neurobiology of Trust
by Frank Krueger

IN THE SPOTLIGHT

Brain Lab at
Kennesaw State University

YOUNG ACADEMICS

Colin Conrad
Dalhousie University

Preface

Dear Readers!

Information Systems (IS) is a scientific discipline that investigates the design, development, use, and impact of information and communication technologies. Since its genesis in the 1960s, IS research has drawn upon knowledge from references in multiple disciplines, which has contributed to its interdisciplinary nature. Examples are psychology, sociology, economics, management, and computer science. Concepts and theories, as well as methods and tools, from these and further disciplines have contributed to the prosperous development of the IS discipline. Considering the current and predicted importance of digital technologies, it is hardly possible to imagine a scientific landscape without the IS discipline. Smartphones, artificial intelligence applications, enterprise systems, among many other information and communication technologies and digital tools, penetrate almost every corner of life, thereby significantly influencing individuals, businesses, and society.

Fifteen years ago, a small number of IS researchers—partly independently from each other—developed the idea of applying neuroscience knowledge and tools with the goal to advance IS theory and practice. Today we know that NeuroIS has become a prosperous scientific field, and neuroscience constitutes an important reference discipline for IS research.

Shortly after the genesis of the NeuroIS field, an annual scientific meeting was launched, the NeuroIS Retreat. The inaugural meeting took place in Austria in 2009 and brought together interdisciplinary researchers from around the world to discuss research that leverages neuroscience theories and methods to tackle research problems in IS. This year, the NeuroIS Retreat takes place the 14th time. A huge number of researchers from all over the world, ranging from established world-class scholars to young students who seek to develop their own academic identity in a highly innovative research field, participated at the meeting—thereby they contributed to the advancement of knowledge and the design of innovative systems.

Considering the increasing calls in the research community to develop institutional structures and processes, a few years ago a group of 20 scholars from different scientific disciplines—including IS and computer science, neuroscience and brain research, and psychology—decided to found the NeuroIS Society. This organization is the premier academic organization for scientists and professionals working at the nexus of IS, digital technologies, and neuroscience research and development. The NeuroIS Society is a non-profit organization and was founded in Vienna, Austria, in 2018. The bylaws define that the main purpose of the organization is to support basic and applied research in the field of NeuroIS, also in connection with practice. Development of NeuroIS knowledge and possible applications of that knowledge are important factors.

Since its genesis, the NeuroIS Society has contributed to the prosperous development of NeuroIS. Among several other actions, the NeuroIS Society aims to support collaborations with related organizations and institutions. As important examples, we emphasize our intellectual exchange with the Association for Information Systems (AIS) and the brain-computer interface (BCI) research community. The Society's board and founding members, as well as many other scholars worldwide, introduced and showcased the "NeuroIS idea" in other scientific fields and in practice in the past years.

However, despite its past achievements, the NeuroIS Society works untiringly to substantiate its leading role in the advancement of the NeuroIS field. Against this background, recently the Society's board decided to launch the NeuroIS Society Magazine. The main goals of this publication are to inform the NeuroIS community about important current and future developments, to provide a retrospective account of significant events in the past, and to introduce research groups and community members to a larger audience. Importantly, despite the fact that the magazine's primary intended readers are active NeuroIS researchers and interested organizations and people in practice, we also foresee interested readers beyond these groups. Therefore, with the magazine we also want to inform scholars in other scientific disciplines as well as policy makers in practice, such as those from funding agencies, about the significance of NeuroIS research and its huge potential to result in notable improvements in economy and society. In his contribution to the 10 Years Anniversary Book of the NeuroIS Retreat, the Austrian President Dr. Alexander Van der Bellen tellingly argued: "Neuro-Information-Systems (NeuroIS) with its focus on the neurophysiological consequences of human interaction with information and communication technologies is at the cutting edge of developments affecting science and society today. The impact of progress in communication and information technology must not ignore the „human aspects" including those related to information processing in the brain. NeuroIS is playing a vital role in this area including the work on innovative systems that support computer users in their task execution in a user-friendly way." In fact, the NeuroIS Society and the research community are proud that our research and development efforts have reached notable visibility. This fact is also signified by the prominence of the keynote speakers of the NeuroIS Retreat, who are typically from the fields of neuroscience, brain research, and psychology.

In this inaugural issue of the NeuroIS Society Magazine, the reader can find several stimulating contributions, reports, and background information on research groups and community members. The table of contents reflects the diversity of topics. We highlight the inaugural issue's cover story on the neurobiology of trust by Frank Krueger.

Enjoy this inaugural issue of the NeuroIS Society Magazine!

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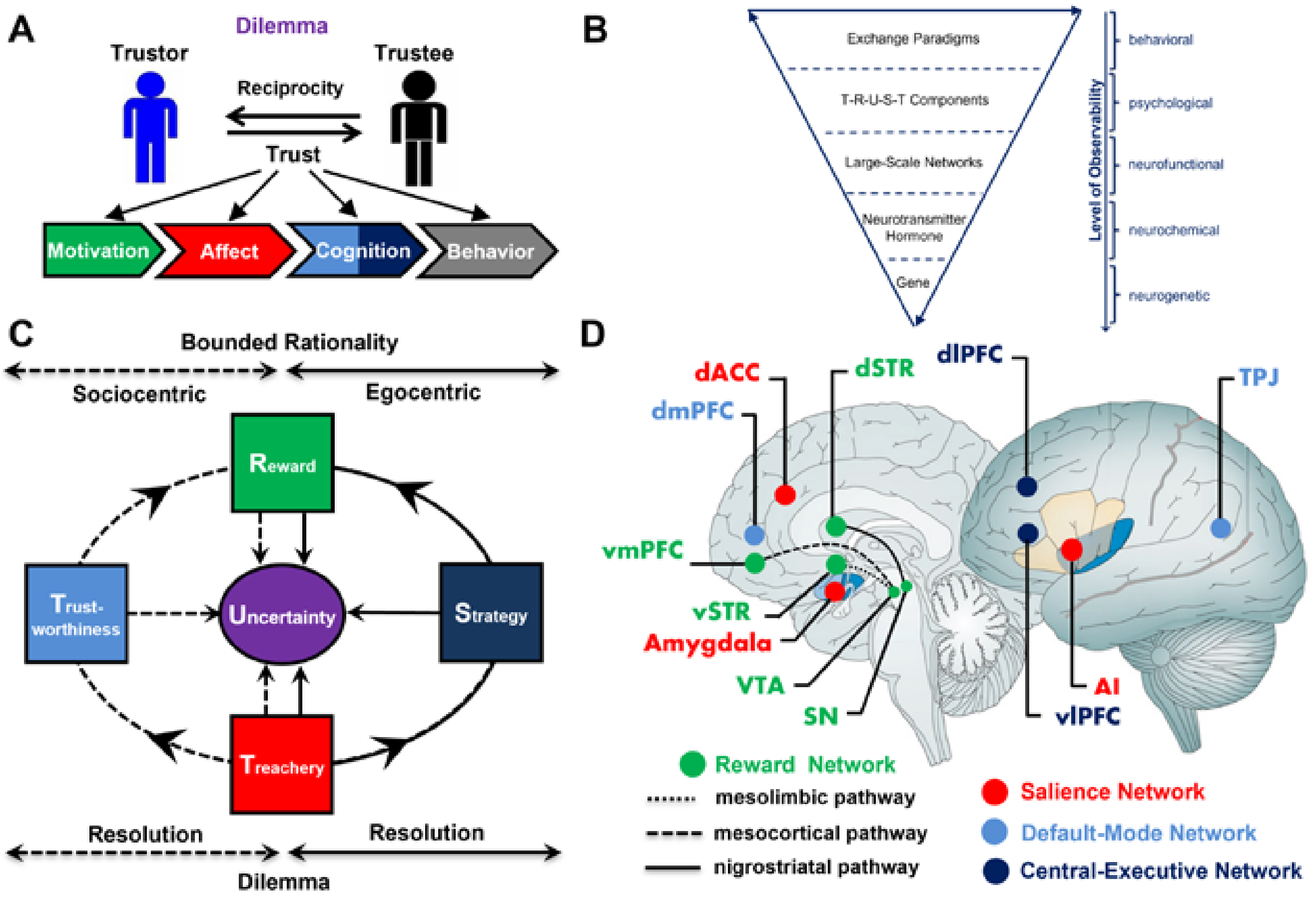
Neurobiology of Trust

by Frank Krueger, George Mason University (USA)

Trust infuses nearly every aspect of daily human lives and drives human productivity across global economic and political domains [1]. Trust not only impacts our human-human social interactions, such as in interpersonal, institutional, and intercultural relationships but also our human-technology interactions with information and communication technologies (ICT) in the development, adoption, and impact of information systems (IS) [2, 3]. Various definitions of the construct of trust exist but recognizing common underlying psychological elements across definitions permits the formulation of a working definition of trust [4]. Trust represents a dilemma that creates uncertainty where a trustor is willing to accept vulnerability to treachery (affect) based on the expectations (cognition) that the action of a trustee will produce some anticipated reward (motivation) due to reciprocity in the future [5] (Fig. 1A). Over the last two decades, a joint effort from scholars with diverse backgrounds (e.g., social psychology, behavioral economics, IS, and cognitive neuroscience) has started to gain a deeper understanding of the neurobiological underpinnings of trust [6-9]. The synergy of various methodologies—combining behavioral paradigms with functional neuroimaging and stimulation methodologies and neuroendocrinological and neurogenetic methodologies—allows integrating knowledge across different observation levels into a neurobiological framework of trust [10] (Fig. 1B).

A recent model of interpersonal trust has been proposed to incorporate research findings across behavioral, psychological, and neural levels [5]. At the behavioral level, interactive experimental paradigms (e.g., economic exchange games) capture the dilemma of trust and measure baseline trust toward strangers during one-shot interactions and trust dynamics in relationship formation during multi-shot interactions [11]. At the psychological level, psychometric and survey measures permit the evaluation of Treachery, Reward, Uncertainty, Strategy, and Trustworthiness (T-R-U-S-T) components that are linked to the psychological systems of trust (i.e., motivation, affect, and cognition) (Fig. 1C). The dilemma of trust generates uncertainty due to the risk of vulnerability (affect) after treachery contrasted with the expectation of reward (motivation) after reciprocity. Due to limits in mental resources and time, two forms of bounded rationality (cognition)—performance-based rationality and morality-based rationality—can be applied to remove uncertainty and therefore to resolve the dilemma. On the one hand, trustors can adopt a context-based strategy by employing executive cognitive functions to reap outcomes based on cost-benefit analyses (i.e., egocentric incentives); thus, resolving uncertainty by transforming the risk of treachery into positive performance-based expectations of reciprocity. On the other hand, trustors can evaluate the relationship-based trustworthiness by employing social cognitive functions to contribute to the relationship's success (i.e., sociocentric incentives); therefore, resolving uncertainty



VTA, vental tegmentum area; **SN**; substantia nigra; **dSTR**, dorsal striatum; **vSTR**, ventral striatum; **vmPFC**, ventromedial prefrontal cortex (PFC); **AI**, anterior insula; **dACC**, dorsal anterior cingulate cortex; **TPJ**, temporoparietal junction; **dmPFC**; dorsomedial PFC; **dlPFC**, dorsolateral PFC; **vlPFC**, ventrolateral PFC.

Figure 1. Neurobiology of Trust. (A) Trust definition. (B) Trust Framework. (C) Trust Model. (D) Trust Brain Networks. Figure adjusted and reprinted with permission from Elsevier Science & Technology Journals [5].

by transforming the risk of treachery into positive moral-based expectations of reciprocity.

At the neurofunctional level, complementary neuroimaging methods (e.g., functional magnetic resonance imaging, electroencephalography, and focal brain lesions) allow identifying the activation and connectivity patterns of large-scale brain networks [12]—reward network (RWN), salience network (SAN), central-executive network (CEN), and default-mode network (DMN)—arising from the interactions of the T-R-U-S-T components (and its associated psychological systems) that engage key regions anchored in those domain-general networks (Fig. 1D). The motivational system is anchored in the RWN that builds on dopaminergic pathways—originating in the ventral tegmentum area (i.e., mesolimbic [e.g., ventral striatum] and mesocortical [e.g., ventromedial prefrontal cortex, PFC] pathways) or substantia nigra (nigrostriatal [e.g., dorsal striatum] pathway) of the midbrain [13]—to determine the anticipated reward for trusting another person. The affective system is embedded in the SAN—including crucial regions such as amygdala, anterior insula, and dorsal anterior cingulate cortex consistently implicated in self-related bottom-up saliency detection for regulating social behavior [14]—to incorporate aversive feelings associated with the risk of treachery by another person. The cognitive system consists of two parts: The cognitive control system is linked to the CEN—comprising the dorsolateral and ventrolateral PFC reliably associated with top-down cognitive control in adopting goal-directed behavior under changing contexts [15]—to adopt context-based strategies for trusting a partner. The social cognition system is associated with the DMN—including crucial brain regions such as the temporoparietal junction and dorsomedial PFC consistently identified in the context of mentalizing about others to facilitate cooperative decision making [16]—to evaluate the relationship-based trustworthiness for trusting a partner.

At the neurochemical level, pharmacological manipulations of hormones (e.g., oxytocin, OT; testosterone, TE) and monoamine neurotransmitters (e.g., dopamine, serotonin, norepinephrine) reveal the neural signaling pathway mechanisms involved in trust behavior—influencing the information processing of trust in local brain regions of the domain-general large-scale brain networks. Being antagonists, the neuropeptide hormone OT (synthesized in the hypothalamus and released to the brain and body) likely acts as a general promoter of trust [17], whereas the steroid hormone TE (dominantly synthesized by testes in men and ovaries in women and released to the body) probably operates as a general inhibitor of trust [18]. Pharmacologic agents such as opiates and ecstasy (i.e., 3,4-Methyl-enedioxy-methamphetamine) impact trust behavior by increasing the activity of monoamine neurotransmitters (acting as endogenous neuromodulators) through stimulating or blocking endogenous receptors directly by targeting specific receptor types or intervening in the cellular reuptake or synaptic metabolism of those endogenous neuromodulators [19]. At the neurogenetic level, twin and gene-specific candidate-driven studies looking at individual variations in the human genome and variants of single-nucleotide polymorphisms (SNPs) explain heritability and genetic variation mechanisms in producing individual differences in trust. By comparing monozygotic and dizygotic twin pairs, twin studies show a genetic effect on trust behavior between 10% to 20% [20]. Gene-specific candidate-driven studies identified SNPs in a few genes—oxytocin receptor gene, arginine vasopressin receptor 1A, dopamine D4 receptor gene, and serotonin transporter gene—modulating trust levels [21].

As a significant milestone in understanding the neurobiological signatures of trust, the proposed framework/model can serve as a common basis for a Transdisciplinary Research Union for the Study of Trust (T-R-U-S-T) to facilitate, broaden, and improve the current state of trust research. While the current framework/model has started to illuminate the behavioral, psychological, and neurobiological processes of human-human trust, it faces challenges in terms of trust-related human-technology interactions that must be addressed. For example, the integration into a broader neurobiological model of trust can guide future investigations to understand better both fundamental and applied NeuroIS research [22]. Such a unified framework/model could facilitate the development of new theories in identifying the antecedents, formations, and temporal dynamics of trust and the design of innovative ICT artifacts that activate the appropriate dispositions and neural signatures for building trust. As the T-R-U-S-T initiative matures, the success of an overarching neurobiological framework/model of trust with high relevance and impact on our everyday lives and practical implications in diverse ICTs sectors will positively affect outcomes for individuals, groups, and society.

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NeuroIS Retreat Keynote Speakers at a Glance

Since the inaugural retreat in 2009, distinguished keynote speakers from various scientific fields provided their perspectives on important topics and methods related to NeuroIS research. Their valuable insights contributed significantly to the prosperous development of the NeuroIS research community. The following list summarizes all persons who served as keynote speakers at the retreat in the period 2009 – 2022. Names are listed in alphabetical order.

Antoine Bechara
University of Southern California (USA)

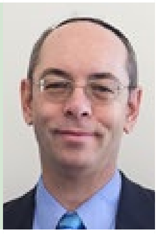
Decision Neuroscience: How It Started and Where We Are Today

Alan R. Dennis
Indiana University (USA)

NeuroIS as Qualitative Research: Solving the Reverse Inference Problem

David Gefen
Drexel University (USA)

How to Tell your NeuroIS Story to a Management Information Systems Audience

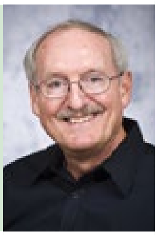


Hauke Heekeren
Freie Universität Berlin (Germany)

Social Media and the Brain

Alan R. Hevner
University of South Florida (USA)

NeuroDesign Research in Information Systems: A Proposal



Anja Ischebeck
University of Graz (Austria)

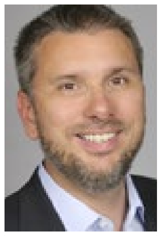
An Introduction to fMRI
The Search for Information

Tobias Kalenscher
Heinrich-Heine University (Germany)

Why Do We Need Animals to Understand the Neurobiology of Economic Decision-making?

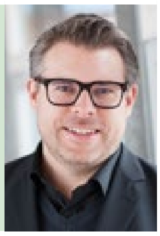
Frank Krueger
George Mason University (USA)

The Neurobiology of Trust: Benefits and Challenges for NeuroIS



Christian Montag
Ulm University (Germany)

Towards a New Research Discipline Called Psycho(neuro)informatics: Empirical Evidence from the Investigation of the Psychobiological Basis of Internet Addiction



Gernot R. Müller-Putz
Graz University of Technology (Austria)

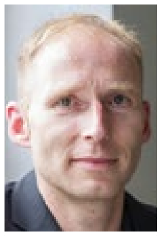
Non-Invasive Brain-Computer Interaction: An Overview
Hybrid Brain-Computer Interfacing: Principles and Applications

Christa Neuper
University of Graz (Austria)

Brain-Computer Interaction

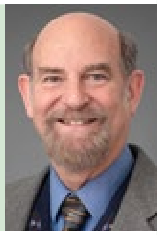
Martin Reuter
University of Bonn (Germany)

Genetic Approaches to the Field of NeuroIS
New Developments in NeuroIS: The Power of the Genes



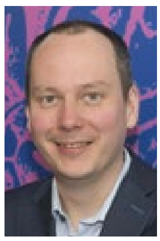
Robert L. Savoy
Harvard Medical School & Athinoula A. Martinos Center for Biomedical Imaging (USA)

The Interaction and Complementarity of Behavioral Research with Functional MRI
Studying Connectivity in the Brain via MRI: Concepts and Methods



Bernd Weber
University of Bonn (Germany)

Neuroeconomics: On the Biological Basis of Human Decision Making
Translational Behavioral Neuroscience: The Use of Neuroscientific Insights to Improve Public Welfare



Reconnecting with Society: Using NeuroIS to Help Users with Severe Motor Disability

by Pierre-Majorique Léger, Tech3lab, HEC Montréal (Canada)

An interview with an inspiring researcher actively involved in the promotion of women in science: **Dr. Adriane B. Randolph**, Executive Director of the BrainLab at Kennesaw State University

Pierre-Majorique: Bonjour Adriane, thank you very much for participating in this interview! This is the inaugural issue of our NeuroIS Society Magazine, and we have decided to choose you and your Lab at Kennesaw State University to showcase how you are using your science to connect and reach out to the community and impact people's lives. So, first of all, let's start with what is the BrainLab and a short description of this and the work you're doing at the Lab at Kennesaw State.

Adriane: Thank you for the invitation and for being the first interview. So the Kennesaw State University BrainLab is focused on brain-computer interface design, and we are helping primarily people who are living locked into their bodies—locked-in means being completely paralyzed, unable to speak, but cognitively intact. Thus, using their brain waves or their neurophysiological responses is their last frontier to communicate and control their environment. We are using EEG primarily, with non-invasive techniques meaning sensors placed on the scalp to serve as input recording brain waves to anything with a microchip, such as a computer or an application on a mobile phone.

Adriane B. Randolph with a study participant

Pierre-Majorique: Give me an example of an artifact that you have been working on in your research to enable this population of users to interact with information systems.

Adriane: I appreciate you framing it that way around users, because these are individuals who have a severe motor disability and we are looking to help them reconnect with society. So it could be a teenager looking to have more independence from his parents and have a social life, to be able to use Facebook or other similar social media platform.

Pierre-Majorique: How does it work?

Adriane: Facebook has a very friendly API for connecting where, for example, we designed an interface based on the P300 response where the prebuilt communication areas for Facebook we piped into this grid form and the person was able to select and send a message, and they can refine their message by using the speller matrix. These developments have been used to improve significantly the independence of patients.

Pierre-Majorique: You are really known for your ability to leverage NeuroIS to reach the community in your region in the United States. Talk to us about how you do that.

Adriane: For one, we are a service project to a larger brain-computer interface research group called The Wadsworth Center located in Albany, New York USA. And they have established the National Center for Adaptive Neurotechnologies (NCAN). We are essentially involved in the region around Atlanta, Georgia to go out and meet with patients, their families, and their caregivers to understand their needs. We put sensors on them to see if we can do data classification and if the system can work well to be beneficial to them. That is kind of the excitement and the stress of the work because brain-computer interfaces are not yet mainstream like iPhone use at this point. For in-home use, we still essentially need someone who knows the technology and a bit of neuroscience to come and place sensors on and walk you through different scenarios to have your brain respond to the stimuli.

Pierre-Majorique: What is fascinating, and what I really love about your science and your research is that it really impacts people's lives and you can really transform their daily lives. That must be really rewarding!

Adriane: It is! I often roll in with a "bag of hope" because I have a whole suitcase of the equipment like a monitor, a laptop, all of the EEG equipment—the whole thing! And I go through the process of setting it up and really disrupting their environment because they are often at home, getting care. To say to the family that I believe that your loved one is in there, and we just need to give them an avenue for response is incredible. There have been moments where I think the families did not realize how close

Adriane B. Randolph and her team (BrainLab at Kennesaw State University)

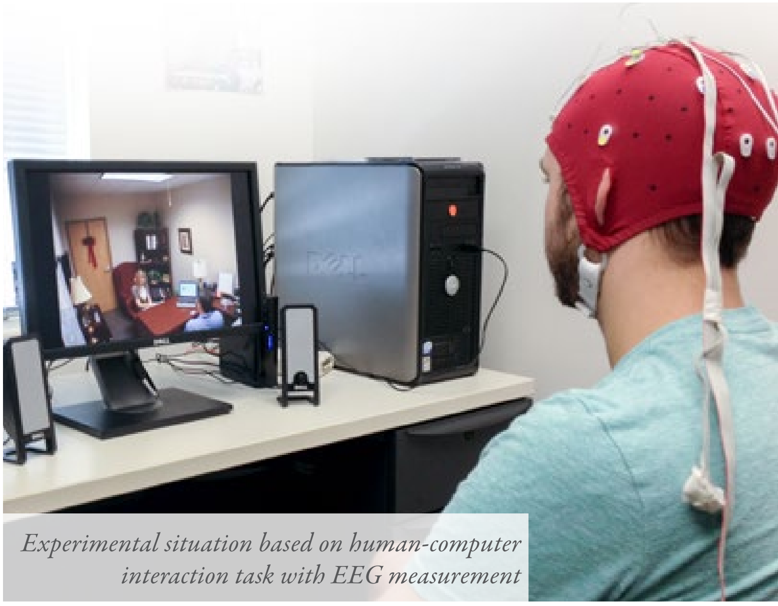
they were to giving up their hope; they were taking care, the person was being well-cared-for in-home, but it was not until I brought the sensors, set them up, and go, when there is a breakthrough. It happens during that moment —seeing, in this case, the neuro-related signal having a distinct fluctuation during that time in response to a verbal command for the person to think of something. Oh my goodness! I mean, I think about this time on the West Coast where we were working with this family, and they were in tears. And I am just there, doing what I do.

Pierre-Majorique: You are a role model, I believe, for the Information Systems research as a topic of research that not only advances the science but really impacts people's lives. I know how you are also involved in STEM research and making sure that women advance in STEM. Can you maybe talk about how you are promoting that in your lab and how you are trying to encourage this new generation of women in science.

Adriane: It actually ranges from K12 to all levels of college students. I do talks in K12 schools and invite families to come to the Lab. At the University level, it is often women that are attracted to this, and I can only say it is because of who I am, as a woman in STEM. I look at the members of our Lab who naturally gravitated here and it is often an all-woman team—with maybe one man. And we are surely not turning anyone away! Also, for me it is just not women and STEM, it is also people of color. For me, this is especially important as a Black or African-American woman. I know the race construct is perceived differently across countries and regions, but someone who looks like me is not as often involved in neuroscience and neuroscience-related studies. There are challenges with the equipment and understanding the impact of cultural differences, such as hairstyles. I get it, and that is why I am purposefully choosing certain equipment and bringing people in. It is a whole contextual shift, understanding the angles and how we get there and the different perspectives. Related,—I am very excited to say—a Black woman in my Lab has recently gone on to a Ph.D. program at the University of Washington . It is neat to see how we may have impact in a range of intersecting areas such as information systems to machine learning and algorithms... I am excited to bring diverse voices and experiences to the field.

Pierre-Majorique: I congratulate you, and I am admirative of this work you are doing and I am delighted that I have chosen you for this very first interview. I think it sends this message of how, as researchers, we definitely, you know, are always talking about the basket of publications and may be losing sight of the bigger picture. We are here to improve humanity, and I feel that is reflected in your work, and the process by which you are trying to achieve your goal is significant. Thank you so much.

Adriane: It helps to have a community and folks like you to be encouraging. I have found those supporters early on through the human-computer interaction special interest group within AIS and now through the NeuroIS community.



Experimental situation based on human-computer interaction task with EEG measurement

Startle Reflex Modulation: A Way to Measure Non-conscious Affective Responses Underlying Emotions

by Peter Walla, Sigmund Freud University in Vienna, Faculty of Psychology and Medicine (Austria)

If one wants to watch the brain at work while it processes information the first plan is usually to apply brain imaging technologies. Those are indeed fantastic tools to visualise various brain functions in response to controlled stimulus presentations. However, there is yet another technique that allows for surprisingly accurate comparisons of particularly affective brain responses (affection) to varying stimulus content. The method is known as startle reflex modulation (SRM) [1]. SRM is not a neurophysiological method, it measures neural affective responses indirectly through reflex modulations as a consequence of affective processing. Besides other modulatory influences it has been found that negative affective processing enhances the startle reflex while positive affective processing reduces it, which forms the basis for SRM to be a reliable tool to quantify non-conscious affection [2].

The method originates from animal research (rodents) and has been adapted for use in humans. In humans, it is based on the acoustic startle reflex that consists of various involuntary muscle contractions, among which the eye-blink (contraction of the musculus orbicularis oculi) is the most reliable and the most resistant to habituation component [3]. An eye-blink in response to a short burst (50ms) of white noise acoustically presented to both ears (a startle probe) at a relatively high sound pressure level (around 110dB) is modulated by varying activity levels of subcortical neural structures (central nucleus of the amygdala and nucleus accumbens) involved in affective processing [4, 5]. Eye-blink modulations can easily be measured via electromyography (EMG; three electrodes) (Fig. 1), which makes SRM a cost-efficient technique to quantify affection, especially in comparison to very expensive brain imaging tools such as functional Magnetic Resonance Imaging (fMRI). Already in 1999, researchers summarized prior literature and mention that affective modulation of the startle reflex has proven to be highly replicable by then ("a relatively rare event in psychological science") [2]. Today, its value is even clearer and the relatively low costs make it indeed an attractive method for both basic and applied research.

One fine aspect of SRM is that it is particularly sensitive to affection independent from cognition. Cognition and affection are two separate and distinct processing pathways in the human brain [6, 7]. Cognition is largely mediated by activation of cortical neurons whereas affection is more depending on subcortical neural activity. This is also mirroring the much older evolutionary age of affection compared to cognition. The independence from cognition means that SRM is in no sense under any conscious control and thus it is not subject to intentional bias. It does not require any explicit response and thus is a purely objective method to quantify affective responses. As long as stimuli have affective aspects (i.e. pleasant or unpleasant) and as long as a study participant is exposed to them SRM can measure and accurately compare affective responses they elicit [8]. Since language is mainly a cortical function and affective responses are at least initially subcortical any explicit response would anyway be only a weak representation of primary affection.

In summary, SRM is an elegant and cost-efficient way to quantify affective responses that underlie any emotions and thus it is highly relevant to much of the research undertaken by scholars of the NeuroIS community [9, 10].

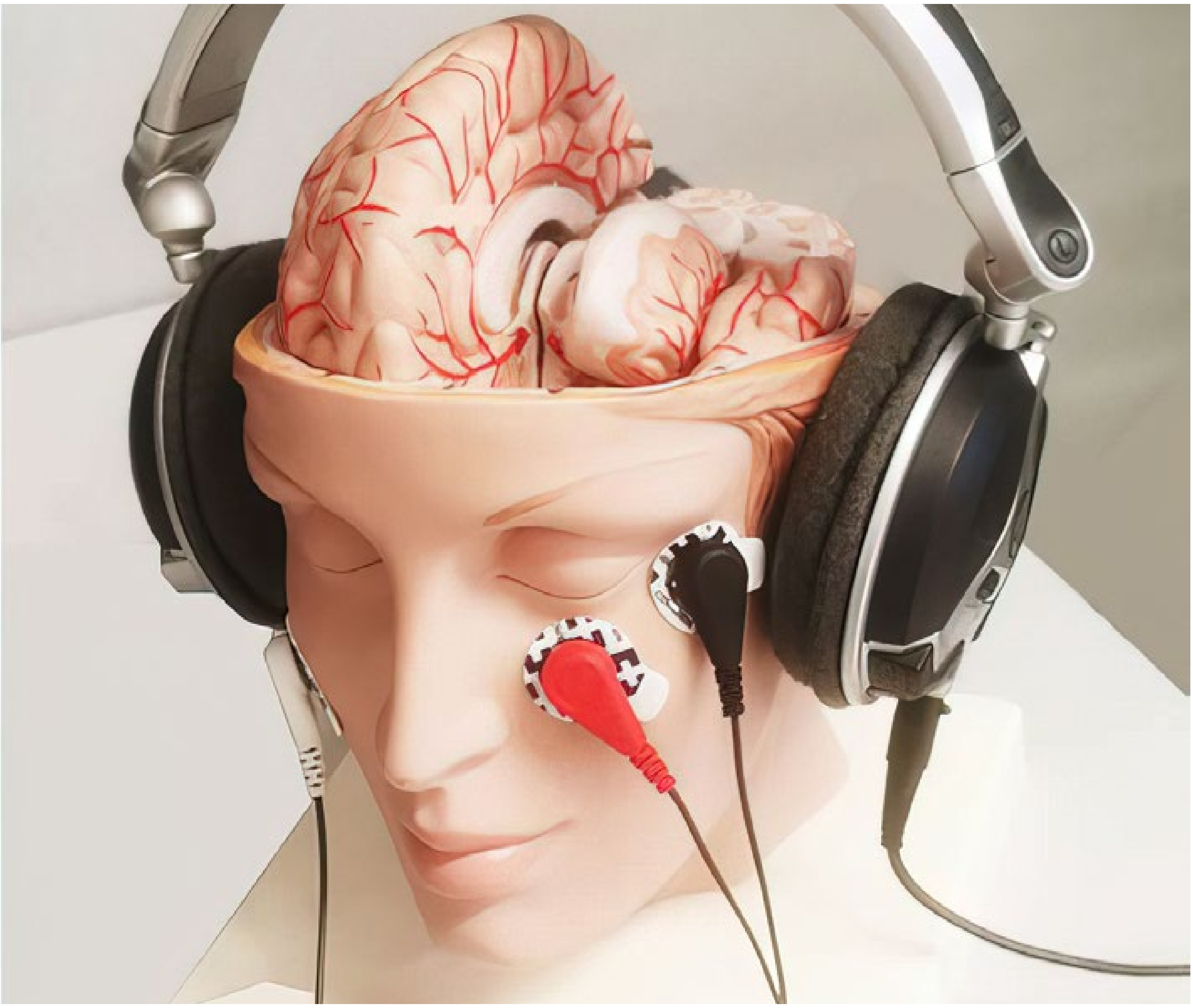


Figure 1. Startle Relfex Modulation. Startle reflex modulation (SRM) can be measured via electromyography (EMG) of the musculus orbicularis oculi of one eye in response to the presentation of a startle stimulus (50ms burst of acoustic white noise delivered by headphones) during the presentation of a foreground stimulus, which represents an independent variable in an experiment (e.g. pictures or words). Two recording electrodes are placed around one eye (see red and black electrodes around left eye of head model) and one ground electrode on the cheek on the other side (white electrode on head model).

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From Neuro-adaptive Systems to Neuro-adaptive Processes: Opportunities of NeuroIS to Contribute to the Emerging Field of Process Science

by Jan vom Brocke, University of Liechtenstein, Institute for Information Systems (Liechtenstein)

A hugely fascinating aspect of NeuroIS is the prospect of developing neuro-adaptive systems [1, 2]—in simple terms, information systems (IS) that are sensitive to emotions and thoughts [3]. A recent research agenda published in the European Journal of Information Systems presents four areas to advance NeuroIS research towards societal contributions: 1) IS design, (2) IS use, (3) emotion research, and (4) neuro-adaptive systems. All four areas contribute to an intriguing new field called Process Science [4], that can further leverage the emission sensitivity of systems to processes, that way making important contributions of value to society. This article further outlines this idea and makes a call for NeuroIS contributions to Process Science.

What is a neuro-adaptive system?

Neuro-adaptive systems are an outstanding example of what NeuroIS research is able to accomplish, which is to build systems that are sensitive to users' affective and cognitive states [3]. Neuro-adaptive systems are conceptualized as sensor-actor networks that are sensitive to human neurophysiological states [5]. Simple systems have already entered the market a while ago, for example, in the form of bracelets that use body data, such as heart rate and skin response [6]. Furthermore, such devices are increasingly used in practical business contexts, e.g., adapting business applications to the sensitivity of users [7]. A conceptual illustration is provided in Fig 1.

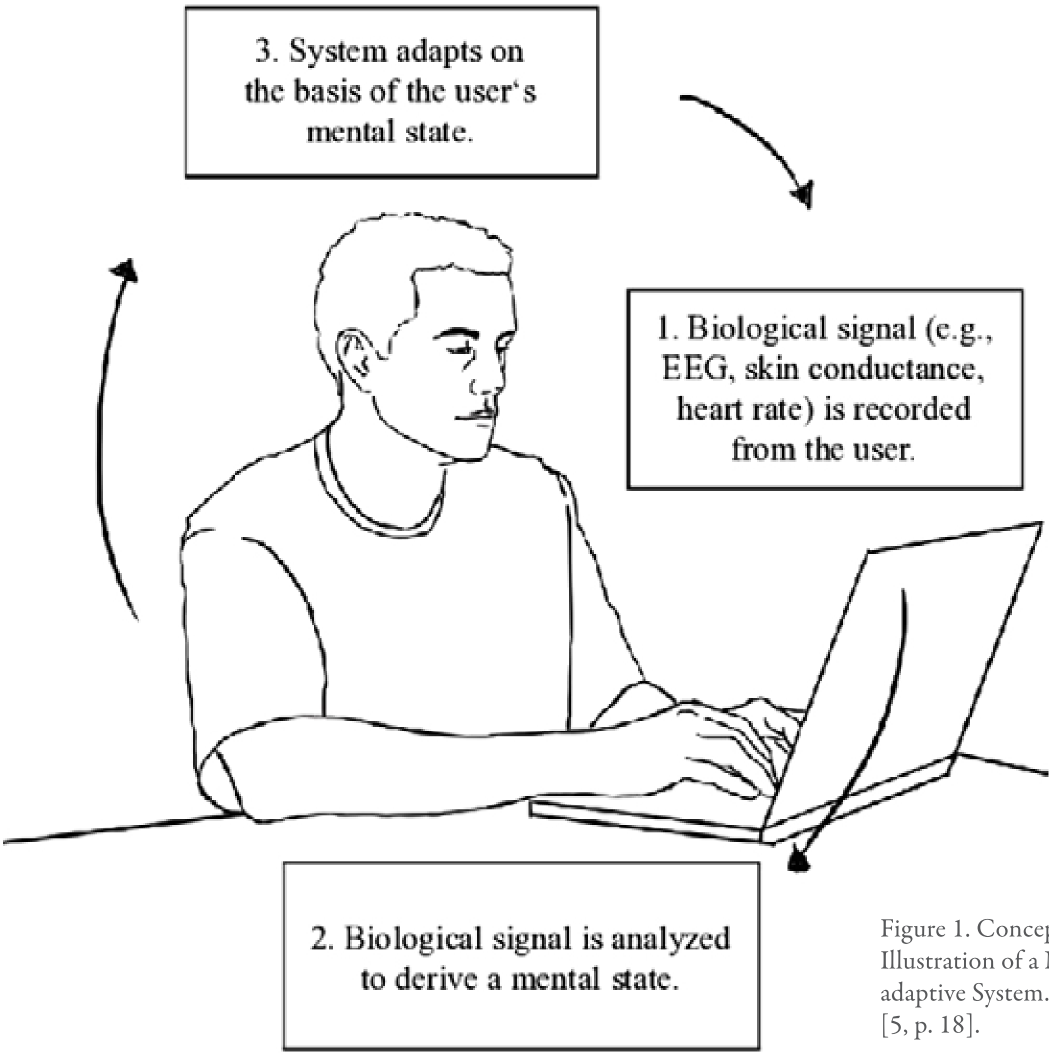

Figure 1. Conceptual Illustration of a Neuro-adaptive System. Source: [5, p. 18].

	Question	NeuroIS
Prescriptive Process Science	How to "do" something?	How can processes be made sensitive towards emotions?
Predictive Process Science	What "will be"?	What emotions can be predicted for certain processes?
Explanatory Process Science	"Why" is something?	Why do people feel in a certain way engaging in processes?
Descriptive Process Science	"What" is and "How" is something.	What emotions occur when engaging in processes?

Figure 2. NeuroIS enabling Neuro-adaptive Process Design

To arrive at neuro-adaptive system design, three application strategies of NeuroIS in Information Systems Design Research have been identified: to (1) inform the design of information systems, (2) evaluate design, and (3) build in NeuroIS functionalities, leading to specific neuro-adaptive systems [8].

Moving from systems to processes

If neuro-adaptive systems are so fascinating, then why move towards neuro-adaptive processes? The reason is that work and life today are in no way limited to the use of certain systems, but instead evolve in processes that span multiple systems while constantly changing over time and according to context. We live in an age of processes. Many core phenomena of our time raise the issue of complex dynamics involving change. What these phenomena have in common—whether climate change, globalization, the platformization of economies, such societal movements as #meToo, #FridaysForFuture, #blackLivesMatter, or even the decisions made by politicians// as well as political decisions—is that we can learn a lot more about them if we think of them as ongoing processes, rather than as stable objects or systems.

To study these and other contemporary phenomena, we need to embrace the fact that the only constant in our world is change. Phenomena unfold, evolve and wane, and occur on a macro, meso, and micro level. Our world is not made up of things, it is made up of processes that change everything around us [9, 10]. However, a view that sees the world primarily as flowing as opposed to being in a stable state is by no means trivial. It goes against many of our deeply ingrained assumptions premised on the view that the world espouses stability and permanence. The latter assumption has been at the core of scientific investigation, focusing on objects, their properties and relationships. In contrast, an orientation towards processes—broadly defined as the ordering of change—embraces a view of the world that is evolving and becoming [11].

The study of neuro-adaptive processes

Process science is a promising field of research [4] that builds on the collection and computation of extensive digital data, such as the information collected by sensor technology and social media to capture and discover real-world processes (descriptive process science); it analyses such data in a rich empirical context to better understand processes, e.g., how economic behavior affects environmental change (explanatory process science), and also develops innovative solutions to be used in practice to influence change for the benefit of the economy and society (prescriptive process science).

Specifically, process science aims to integrate various sources of data, including neuro-physiological data, to better understand and intervein with processes, in order to enable neuro-adaptive processes. An early example was presented by Léger, Riedl, and vom Brocke who measured electrodermal activity (EDA) with performing workflows running the business simulation game ERPsim. The study found that experts' emotional responses led to their sourcing information from the ERP, while novices' emotional responses led to their sourcing information from other people [12].

NeuroIS has a huge opportunity to contribute to process science in making processes sensitive towards people's emotions. NeuroIS can provide a more comprehensive understanding and more people-centered design of processes at four levels:

- First, NeuroIS can aim at identifying (and tracing) the emotional effects processes have on people. That way, NeuroIS can contribute to descriptive process science by more comprehensively assessing processes. NeuroIS devices, such as smart watches, can capture body data and send related events (e.g., arousal levels) to an event log data basis used to identify and discover processes. Conventional event logs would contain performance data from enterprise resource planning systems, which can be enriched by body data to capture the emotional effects processes may have on individual users in specific contextual situations.

- Second, NeuroIS research can contribute why certain emotions are stimulated in processes. Computational analysis can identify patterns in the event logs, including events documenting emotional states of users while engaging in a process. Empirical data—derived, for example, from interviews or archival analysis—can be taken into account to foster explanations. NeuroIS can provide revelatory explanations for how people experience and respond to change, which advance our theoretical understanding of how change evolves in organizational contexts in a way that takes people's emotions into account.

- Third, NeuroIS can help predict the effects processes have on people's cognitive and affective state. Such predictions support planning, managing, and designing processes by taking into account the emotional effects that different choices of design may have.

- Fourth, NeuroIS can enable neuro-adaptive processes—that is, processes which are sensitive towards the neuro-physiological state of people involved in the process. By capturing body data and computing it in real-time, processes can be designed that automatically adjust and respond to the emotions of, for example, employees or users and customers experiencing a process.

Future research should create living labs to capture data "in flight", and NeuroIS could then add a key data source to such labs: specifically, data assessing the cognitive and affective states of people involved in these processes. As research has identified people's individual perception as one of the key enablers or prohibitors of change, such contributions will be a major leap in our capacity to build processes that meet the grand societal challenges of our times.

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The Practitioner's Perspective

An Interview with Dr. Hermann Sikora

NeuroIS Society: Dr. Sikora, you have been supporting the NeuroIS Retreat for several years now, why?

Hermann Sikora: Some time ago I became aware of NeuroIS research. Using methods and knowledge from neuroscience to better understand human behavior in the context of digital technology development and use constitutes a promising scientific approach, which also holds great potential for improvement and interventions in companies. Moreover, it is great that a leading academic conference like the NeuroIS Retreat is taking place in Austria.

NeuroIS Society: NeuroIS research has been around for approximately 15 years. What are the greatest achievements in your opinion?

Hermann Sikora: Well, first I believe that the establishment of a new discipline itself is an achievement. Second, as the CEO of a leading Austrian software company and of a data center servicing banks, I think that the NeuroIS community has succeeded in demonstrating the application potential of most of their studies. In particular, I observe the current developments regarding the development of neuro-adaptive systems and also the application potential of neuroscience approaches to study software development processes. In other words, the great design and engineering potential of NeuroIS stands out.

NeuroIS Society: In your role as CEO, what are the most pressing issues in practice in the context of digitalization and digital transformation?

Hermann Sikora: Good question! In addition to technological complexities, which we always have to solve, and some further challenges which are related to organizational themes such as those related to consideration of more and more regulations in the banking industry, I think that it has always been a challenge to convince people of the necessity for change. Thus, the focus on "people management" is highly critical.

NeuroIS Society: What do you exactly mean?

Hermann Sikora: Let me give you two examples. The first one is related to software development. Increasingly more it becomes important to consider software engineers' wishes and preferences, for example those related to the working environment and conditions in the context of agile development. The second example concerns users. How can we design and implement software, or user interfaces, which are maximally accepted by users?

NeuroIS Society: The good news is that NeuroIS has already contributed to these problem domains, especially to the study of the neural effects of user interface perception.

Hermann Sikora: Yes, I have already seen some interesting research findings and applications during my attendance at the 10 years anniversary ceremony of the NeuroIS Retreat in 2018. Moreover, I found interesting research results in the meeting proceedings.

NeuroIS Society: The NeuroIS Society wishes you all the best for the future. Moreover, we would like to take this opportunity to thank you for your appreciated support of our research community!

Hermann Sikora: Thanks, and all the best too!

Hermann Sikora

Dr. Hermann Sikora is CEO of Raiffeisen Software GmbH, Linz/Vienna, a specialist for banking software, and of GRZ IT Center GmbH, Linz, one of the largest Austrian banking data centers. He studied business informatics and computer science, both at the Johannes Kepler University Linz, which also awarded him the dignity of "Honorary Professor for Information Engineering" in 2006.

Young Academics

In each issue of the magazine, the NeuroIS Society presents a young and aspiring academic.

Colin Conrad

School of Information Management – Dalhousie University (Canada)

Why did you start NeuroIS research?

It all started in 2013 when I had a crazy idea for a startup. I was interested in how Facebook sort of "sucked-in" their users by triggering a state that I now understand as flow. My idea was that we could create a tool that could detect flow through a web browser, and then intervene to help you manage Facebook addiction. We called it "Nudge It" and I (together with a team of would-be student entrepreneurs) won a pitch competition for this idea.

It turns out was a terrible idea for a startup. You can't easily make money by getting people unaddicted to something, though admittedly, perhaps that idea would have had more traction today. The idea was nonetheless a fantastic start to a NeuroIS research programme. Though I began trying to understand how IT triggers flow I am now more interested in the broader role that cognitive states play during IT use experiences, such as the role of mind wandering when attending online meetings.

How did you start with NeuroIS?

I initially had a hard time finding other IS researchers who were interested in neuroscience, though learned about NeuroIS when attending the International Conference on Information Systems (ICIS) 2016. I attended the 2017 NeuroIS retreat which had a training workshop and the following year I presented some papers at the retreat. I was particularly impressed by the collegiality of the NeuroIS community and the willingness of senior scholars to give high quality formative feedback. I can't emphasize enough that the wiliness among NeuroIS researchers to build each other up, rather than tear each other down, contributed directly to by success in landing a tenure-stream role in academia.

What are challenges for young NeuroIS researchers?

Young NeuroIS researchers have the challenge of bridging very different research cultures. The wider information systems and business informatics communities already draw from multiple reference disciplines and are rapidly changing in their methodologies. In addition, younger NeuroIS researchers have to contend with neuroscience, yet another reference discipline, that does not obviously contribute to the goals of business or computer science schools. We have to get good at showing why the brain matters. I also think we have to get really good at ensuring that we can teach cool stuff in our departments.

What were the most important moments in your academic career?

In hindsight, the single most important moment in my career was when I decided to pursue graduate studies in business and computer science earnestly. A close runner up was when we had Chicago deep dish pizza with the NeuroIS group at the 2019 Society for Neuroscience conference. With those events I was able to confidently answer the question: "who is your research community?" during reappointment evaluation. The commitment of the NeuroIS community to building each other up is our secret weapon. Though we face big challenges, a collegial community can go a long way to helping overcome them.

Colin Conrad at the NeuroIS Retreat 2019

Colin Conrad at the NeuroIS Retreat 2018

Colin Conrad at the 2019 annual meeting of the Society for Neuroscience in Chicago

EEG analysis with MNE-Python

by Clemens Brunner, University of Graz (Austria)

MNE-Python is an open-source package for exploring, analyzing, and visualizing neurophysiological data. Originally developed for electrophysiological signals such as EEG, MEG, and ECoG, the package has recently added support for NIRS as well.

MNE-Python covers all aspects of a typical analysis workflow. Importing recorded data from a file is almost always the first step. The package supports over twenty different file formats, including EDF, BDF, GDF, CNT, BrainVision, FIFF, and many more.

"Within only ten years, the MNE-Python developer community has made this open-source package an international reference for analyzing EEG and MEG data."
Alexandre Gramfort

Once the data has been imported, preprocessing is usually necessary to enhance signal quality. MNE-Python includes many state-of-the-art methods such as independent component analysis (ICA), automatic detection of ocular activity, temporal as well as spatial filters (such as common spatial patterns, signal-space projection, or xDAWN), and more. Visual inspection of the signals is also possible with the integrated signal browser (Fig. 1), which facilitates manual artifact selection and inspection of annotations associated with the data.

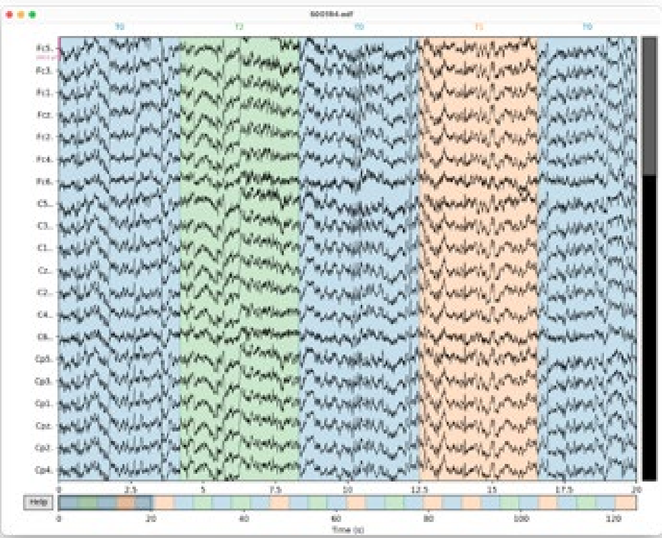


Figure 1. Interactive data browser. Colored segments correspond to different data annotations.

MNE-Python includes various ICA algorithms such as (Extended) Infomax and FastICA. If the Picard package is installed, convergence is extremely fast (especially when compared to other commonly used ICA implementations).

The package supports both event-related potentials (ERP) and time/frequency analysis workflows. Fig. 2 shows a plot which compares ERPs between two conditions (clearly, a P300 emerges for the rare condition).

Oscillatory activity can be inspected with time/frequency maps, for example to analyze event-related (de)synchronization (ERD/ERS) with so-called ERD/ERS maps. It is also possible to map values of interest to a topographic cartoon head or realistic head model.

Mapping signals measured with surface EEG electrodes to cortical sources, a procedure known as source localization, is one of the core strengths of MNE-Python. Many popular methods are supported, including minimum norm estimation (MNE), dynamic statistical parametric mapping (dSPM), low resolution brain electromagnetic tomography (LORETA), beamformers, and dipole fitting.

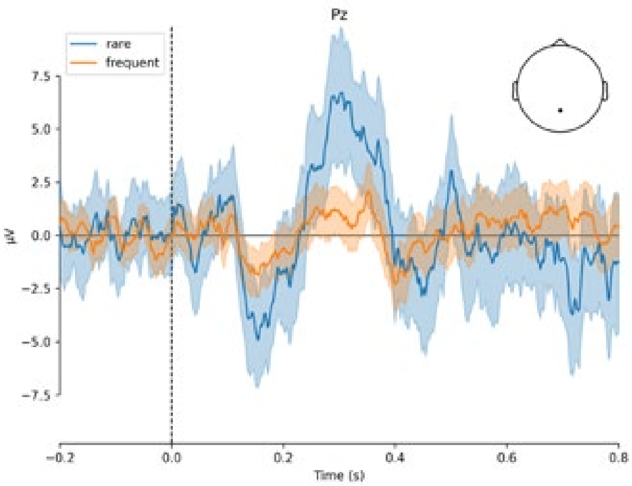
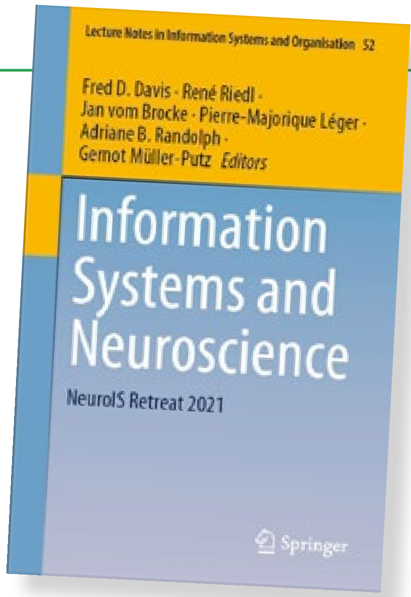


Figure 2. Comparing ERPs (P300 in this example) between conditions. Shaded ribbons correspond to 95% confidence intervals.

In addition, MNE-Python includes modules for connectivity estimation, machine learning, parametric and non-parametric statistical tests, and many different data visualization methods.

Details, including numerous examples and tutorials, are available in the documentation. MNE-Python also hosts a dedicated forum, and core developers hold bi-weekly office hours, where all kinds of questions (related not only to MNE-Python, but also to neuroscience in general) can be asked. A graphical user interface called MNELAB is also available separately for users who are not (yet) familiar with Python.

NeuroIS Retreat Proceedings



The NeuroIS Retreat was started in 2009. Since 2015, the conference proceedings are published by Springer. A total of 251 research papers have been published in the period 2015 – 2022 in the proceedings. Importantly, research-in-progress papers are also published in the proceedings, and the NeuroIS Society is proud that several papers which were originally presented at the annual conference were ultimately published in top journals in the Information Systems (IS) discipline, such as Management Information Systems Quarterly, Information Systems Research, or Journal of the Association for Information Systems. Springer Link data indicates the impressive number of 182,300 downloads of the proceedings (April 2022). It follows that the research presented at the NeuroIS Retreat and published in the proceedings has significant impact.

Sponsors, Supporting Institutions, and Partners

The NeuroIS Society would like to thank all sponsors, supporting institutions, and partners. Without their support, the achieved progress and advancements in the field would not have been possible.

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Looking Back

On this last page, we look back to a highlight in the history of NeuroIS.

Inaugural NeuroIS Retreat in 2009

Group picture of the inaugural NeuroIS Retreat

Gmunden, a small summer resort in Austria, was chosen as the scene for the inaugural NeuroIS Retreat. The meeting took place from September 22 to 24, 2009. The meeting brought together a small group of Information Systems (IS) and neuroscience researchers to consider the promise of leveraging neuroscience knowledge and tools in IS research. The retreat participants developed a research agenda, published in two papers [1, 2], and proposed continuing the event annually.

The following researchers participated at this historical meeting: Rajiv D. Banker, Izak Benbasat, Fred D. Davis, Alan R. Dennis, Angelika Dimoka, David Gefen, Alok Gupta, Anja Ischebeck, Peter H. Kenning, Paul A. Pavlou, Gernot Müller-Putz, René Riedl, Detmar W. Straub, Jan vom Brocke, and Bernd Weber.

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