Reference Syllabi

Association for Information Systems (AIS)

Neuro-Information-Systems (NeuroIS)

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Background

NeuroIS is a field in Information Systems (IS) that makes use of neurophysiological knowledge and tools to better understand the development, adoption, and impact of information and communication technologies (ICT). The idea of applying cognitive neuroscience approaches in IS research appeared at the 2007 International Conference on Information Systems (ICIS) and at two pre-ICIS meetings (Sixth Annual Workshop on Human-Computer Interaction Research in Management Information Systems and OASIS Workshop 2007); a very limited number of publications on ICT and brain research were published in IS outlets before 2007.

NeuroIS examines topics lying at the intersection of IS research and neurophysiology. Specifically, NeuroIS research comprises conceptual and empirical works, as well as theoretical and design science research. It includes research based on all types of neurophysiological tools, such as functional magnetic resonance imaging (fMRI), electroencephalograhy (EEG), fNIRS (functional near-infrared spectroscopy), electromyography (EMG), hormone assessments, or skin conductance and heart rate measurement. Moreover, it is foreseeable that quantitative and molecular genetics could play a significant role in future NeuroIS research.

Analysis of the extant NeuroIS literature shows that papers address the following topics, among others: employment of neurophysiological knowledge and tools to examine trust, technostress, website design, technology adoption, human-computer interaction, emotions in e-commerce, information behavior, IS design science, mental workload, social networks, usability, software development, and business process modeling and enterprise systems. Also, software prototypes of NeuroIS applications, which use bio-signals (e.g., EEG, skin conductance, pupil dilation) as system input, are an essential topic in the field; such systems are referred to as neuro-adaptive information systems. Methodological and ethical discussions are also critical.

Against the background of the fact that NeuroIS has been established as a research field in the IS discipline in the past decade, it is useful to have a syllabus in which the major concepts of the NeuroIS field are documented. More and more universities want to offer a NeuroIS introductory course, often at the graduate level. Based on such a course, students should be able to get an overview of the field in order to make an informed decision about whether, and if so how, they would like to get engaged in NeuroIS research (e.g., PhD thesis).

Importantly, because NeuroIS is a relatively young field, we observe an ongoing development of concepts, and hence this syllabus documents the current state of the field (as it is perceived by the authors of this document). It follows that it is possible that concepts which are considered important today will become less relevant in

the future. Likewise, new topics which have not yet received attention in the NeuroIS literature will become important in the future. Thus, as a consequence of the moderate maturity level of the NeuroIS field, it is important that this syllabus is updated on a regular basis, at least up until a point of consolidation of the concepts in the NeuroIS field is reached.

Purposes and Objectives

We recommend teaching an introductory course to NeuroIS based on the book *Fundamentals of NeuroIS: Information Systems and the Brain* (Springer, 2016). This book provides an introduction to NeuroIS. In addition to this book, we recommend reading seminal papers (for a compilation of NeuroIS papers, both conceptual and empirical in nature, please see *www.NeuroIS.org*).

This introductory course provides a broad overview of NeuroIS. In essence, as indicated in a paper on the foundations of NeuroIS (*Communications of the Association for Information Systems*, Vol. 27, Article 15, p. 245), this field seeks to contribute to the development of new theories that make possible accurate predictions of IT-related behaviors, and to the design of IT artifacts that positively affect economic and non-economic variables (e.g., productivity, satisfaction, adoption, well-being). The course covers fundamental themes, including the following questions:

- What is NeuroIS?
- Why NeuroIS?
- How to conduct NeuroIS studies?
- How to select the right NeuroIS measure given a specific research question?

The course takes a beginner rather than an expert approach to the material presented. As such, it should be of use to students of the Information Systems and Management disciplines interested in neuroscience. A major benefit of the course is that participants are provided with a large variety of NeuroIS topics and tools.

Structure

1. WHAT IS NEUROIS?

Overview

This unit gives an overview of the NeuroIS field, including a discussion of its genesis in 2007 and its development during the past decade. Other important themes in this unit are: foundations of human neurobiology (genetic basics, hormones, nervous system, brain anatomy and functionality), reference disciplines of NeuroIS, and topics addressed in the extant literature.

Learning Outcomes

After the unit participants are able to
- Share the fascination for NeuroIS
- Provide a conceptualization of the NeuroIS field
- Outline the development of the NeuroIS field
- Describe the foundations of human neurobiology
- Outline the reference disciplines of NeuroIS
- Discuss examples of NeuroIS topics (trust, technostress, etc.)

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 1 (Introduction to NeuroIS), Chapter 2 (A Primer on Neurobiology and the

Brain for Information Systems Scholars), Chapter 4 (Topics in NeuroIS and a Taxonomy of Neuroscience Theories in NeuroIS).

- Riedl, R., Banker, R. D., Benbasat, I., Davis, F. D., Dennis, A. R., Dimoka, A., Gefen, D., Gupta, A., Ischebeck, A., Kenning, P., Müller-Putz, G., Pavlou, P. A., Straub, D. W., vom Brocke, J., Weber, B. (2010). On the Foundations of NeuroIS: Reflections on the Gmunden Retreat 2009. In: *Communications of the Association for Information Systems* (27:15), pp. 243-264.

Other suggested readings

- Dimoka, A., Banker, R. D., Benbasat, I., Davis, F. D., Dennis, A. R., Gefen, D., Gupta, A., Ischebeck, A., Kenning, P., Müller-Putz, G., Pavlou, P. A., Riedl, R., vom Brocke, J., Weber, B. (2012). On the Use of Neurophysiological Tools in IS Research: Developing a Research Agenda for NeuroIS. *MIS Quarterly* (36:3), pp. 679-702.
- vom Brocke, J., Riedl, R., Léger, P.-M. (2013). Application Strategies for Neuroscience in Information Systems Design Science Research. *Journal of Computer Information Systems* (53:3), pp. 1-13.
- Riedl, R., Javor, A. (2012). The Biology of Trust: Integrating Evidence from Genetics, Endocrinology and Functional Brain Imaging. *Journal of Neuroscience, Psychology, and Economics* (5:2), pp. 63-91.
- Riedl, R. (2013). On the Biology of Technostress: Literature Review and Research Agenda. *DATA BASE for Advances in Information Systems* (44:1), pp. 18-55. (Note: This journal is also known as *ACM SIGMIS Database*.)
- Further empirical papers on different NeuroIS topics are available in *a Journal of Management Information Systems* special issue (Vol. 30, No. 4, Spring 2014).

2. WHY NEUROIS?

Overview

This unit outlines ten contributions available from the application of neurobiological approaches to IS research and practice. The contributions are divided in two groups: theory (including the measurement of constructs) and design science (engineering). In essence, this unit describes the potential of neuroscience for IS research and practice.

Learning Outcomes

After the unit participants are able to

- Discuss NeuroIS contributions
- Describe the potential of neuroscience for IS research and practice
- Outline why NeuroIS is important for advancements in the IS discipline

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 1 (Introduction to NeuroIS).
- Dimoka, A., Pavlou, P. A., Davis, F. D. (2011). NeuroIS: The Potential of Cognitive Neuroscience for Information Systems Research. *Information Systems Research* (22:4), pp. 687-702.
- Tams, S., Hill, K., Ortiz de Guinea, A., Thatcher, J., Grover, V. (2014). NeuroIS—Alternative or Complement to Existing Methods? Illustrating the Holistic Effects of Neuroscience and Self-Reported Data in the Context of Technostress Research. *Journal of the Association for Information Systems* (15:10), Article 1.

3. HOW TO CONDUCT NEUROIS STUDIES?

Overview

This unit gives an overview of methodological aspects related to NeuroIS research. The unit discusses important concepts of a NeuroIS research methodology. Moreover, an introduction to major neurophysiological tools is given, such as fMRI, EEG, and fNIRS. Also, selected issues related to the establishment and operation of a NeuroIS laboratory are discussed.

Learning Outcomes

After the unit participants are able to

- Describe the presented NeuroIS research methodology
- Discuss selected aspects related to acquisition and analysis of physiological data
- Provide an overview of important issues related to the establishment and operation of a NeuroIS laboratory

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 5 (Establishing and Operating a NeuroIS Lab).
- Riedl, R., Davis, F. D., Hevner, A. R. (2014). Towards a NeuroIS Research Methodology: Intensifying the Discussion on Methods, Tools, and Measurement. *Journal of the Association for Information Systems* (15:10), Article 4.
- Dimoka, A., Banker, R. D., Benbasat, I., Davis, F. D., Dennis, A. R., Gefen, D., Gupta, A., Ischebeck, A., Kenning, P., Müller-Putz, G., Pavlou, P. A., Riedl, R., vom Brocke, J., Weber, B. (2012). On the Use of Neurophysiological Tools in IS Research: Developing a Research Agenda for NeuroIS. *MIS Quarterly* (36:3), pp. 679-702, see Appendix A.
- Dimoka, A. (2012). How to Conduct a Functional Magnetic Resonance (fMRI) Study in Social Science Research. *MIS Quarterly* (36:3), pp. 811-840.
- Gefen, D., Ayaz, H., Onaral, B. (2014). Applying Functional Near Infrared (fNIR) Spectroscopy to Enhance MIS Research. *AIS Transactions on Human-Computer Interaction* (6:3), pp. 55-73.
- Müller-Putz, G., Riedl, R., Wriessnegger, S. (In Press). Electroencephalography (EEG) as a Research Tool in the Information Systems Discipline: Foundations, Measurement, and Applications. Communications of the Association for Information Systems.
- vom Brocke, J., Liang, T.-P. (2014). Guidelines for Neuroscience Studies in Information Systems Research. *Journal of Management Information Systems* (30:4), 211-234.

4. HOW TO USE FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI) IN NEUROIS STUDIES?

Overview

This unit gives an overview of Functional Magnetic Resonance Imaging (fMRI). This technology builds upon magnetic resonance imaging (MRI) scanning technology which measures blood oxygenation in the brain and exploits the different magnetic properties of oxygenated and deoxygenated blood. The unit discusses how fMRI works, the benefits and limitations of this tool, and selected experimental designs and statistical techniques. The unit also reviews how fMRI has contributed to IS research.

Learning Outcomes

After the unit participants are able to

- Describe Functional Magnetic Resonance Imaging (fMRI)
- Discuss the benefits and limitations of this tool in IS research
- Describe experimental designs and statistical techniques used within the fMRI domain

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 3 (Tools in NeuroIS Research: An Overview).
- Dimoka, A. (2012). How to Conduct a Functional Magnetic Resonance (fMRI) Study in Social Science Research. *MIS Quarterly* (36:3), pp. 811-840.
- Hubert, M., Linzmajer, M., Riedl, R., Kenning, P., Hubert, M. (2012). Introducing Connectivity Analysis to NeuroIS Research. *Proceedings of the 33rd International Conference on Information Systems (ICIS)*.

5. HOW TO USE FUNCTIONAL NEAR-INFRARED SPECTROSCOPY (FNIRS) IN NEUROIS STUDIES?

Overview

This unit gives an overview of Functional Near-Infrared Spectroscopy (fNIRS). This tool is another brain imaging technique that uses hemodynamic responses to indirectly measure neuronal activity. The common apparatus is composed of light sources applied on the scalp and light detectors sensitive to the light that is reflected by the different components of the cerebral cortex. The unit discusses how fNIRS works, the benefits and limitations of this tool, and selected experimental designs and statistical techniques. The unit also reviews how fNIRS has contributed to IS research.

Learning Outcomes

After the unit participants are able to
- Describe Functional Near-Infrared Spectroscopy (fNIRS)
- Discuss the benefits and limitation of this tool in IS research
- Describe experimental designs and statistical techniques used within the fNIRS domain

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 3 (Tools in NeuroIS Research: An Overview).
- Gefen, D., Ayaz, H., an Onaral, B. (2014). Applying Functional Near Infrared (fNIR) Spectroscopy to Enhance MIS Research. AIS Transactions on Human-Computer Interaction, 6(3), 55-73.
- Kopton, I. M., Kenning, P. (2014). Near-infrared spectroscopy (NIRS) as a New Tool for Neuroeconomic Research. Frontiers in Human Neuroscience (8), Article 549.

6. HOW TO USE ELECTROENCEPHALOGRAPHY (EEG) IN NEUROIS STUDIES?

Overview

This unit gives an overview of Electroencephalography (EEG). Electroencephalograms, commonly called EEGs, are recordings of the electrical activity of neurons within the cerebral cortex. The unit discusses how EEG works, the history of this technology, the benefits and limitations of this tool, and selected experimental designs and statistical techniques. The unit also reviews how EEG has contributed to IS research in.

Learning Outcomes

After the unit participants are able to
- Describe Electroencephalography (EEG)
- Discuss the benefits and limitations of this tool in IS research
- Describe experimental designs and statistical techniques used within the EEG domain

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 3 (Tools in NeuroIS Research: An Overview).
- Müller-Putz, G., Riedl, R., Wriessnegger, S. (In Press). Electroencephalography (EEG) as a Research Tool in the Information Systems Discipline: Foundations, Measurement, and Applications. *Communications of the Association for Information Systems*.
- Léger, P.-M., Davis, F. D., Cronan, T. P., Perret, J. (2014). Neurophysiological Correlates of Cognitive Absorption in an Enactive Training Context. *Computers in Human Behavior* (34), 273-283.
- Léger, P.-M., Sénecal, S., Courtemanche, F., Ortiz de Guinea, A., Titah, R., Fredette, M., and Labonte-LeMoyne, É. (2014). Precision is in the Eye of the Be-holder: Application of Eye Fixation-Related Potentials to Information Systems Research. *Journal of the Association for Information Systems* (15:10), Article 3.
- Further EEG papers on different NeuroIS topics are available in *a Journal of Management Information Systems* special issue (Vol. 30, No. 4, Spring 2014).

7. HOW TO USE MEASUREMENT OF THE PERIPHERAL NERVOUS SYSTEM (PNS) IN NEUROIS STUDIES?

Overview

This unit gives an overview of several measures of the peripheral nervous system (PNS). Specifically, this unit covers the Electrocardiogram (EKG) and the Galvanometer, two non-intrusive measures that offer great research potential in IS research. The unit discusses how these measures work, the history of the EKG and the Galvanometer, the benefits and limitations of these tools, and selected experimental designs and statistical techniques. The unit also reviews how PNS measurement has contributed to IS research.

Learning Outcomes

After the unit participants are able to

- Describe the Electrocardiogram (EKG) and the Galvanometer
- Discuss the benefits and limitations of these tools in IS research
- Describe experimental designs and statistical techniques used within the EKG and Galvanometer domains

Material

- Riedl, R., Léger, P.-M. (2016). Fundamentals of NeuroIS: Information Systems and the Brain, Springer, Chapter 3 (Tools in NeuroIS Research: An Overview).
- Léger, P.-M.; Riedl, R.; vom Brocke, J. (2014). Emotions and ERP information sourcing: The moderating role of expertise. *Industrial Management & Data Systems* (114:3), 456-471.
- Riedl, R., Kindermann, H., Auinger, A., Javor, A. (2013). Computer breakdown as a stress factor during task completion under time pressure: Identifying gender differences based on skin conductance. *Advances in Human-Computer Interaction*, Article ID 420169.

8. HOW TO USE OCULOMETRY IN NEUROIS STUDIES?

Overview

This unit gives an overview of Oculometry. Oculometry concerns the biometric measurement of the condition and movements of the eye. Generally, even though a person feels as if he or she is controlling eye movements, many micro-movements and pupil-size modifications occur without conscious awareness. The unit discusses how Oculometry works, the benefits and limitations of this tool, and selected experimental designs and statistical techniques. The unit also reviews how Oculometry has contributed to IS research.

Learning Outcomes

After the unit participants are able to
- Describe Oculometry
- Discuss the benefits and limitations of this tool
- Describe experimental designs and statistical techniques used within the Oculometry domain

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 3 (Tools in NeuroIS Research: An Overview)
- Djamasbi, S. (2014). Eye Tracking and Web Experience. *AIS Transactions on Human-Computer Interaction* (6:2), 37-54.
- Cyr, D., Head, M., Larios, H., and Pan, B. (2009). Exploring Human Images in Website Design: A Multi-Method Approach. *MIS Quarterly* (33:3), 530-566.
- Léger, P.M., Sénecal, S., Courtemanche, F.; Ortiz de Guinea, A., Titah, R., Fredette, M., and Labonte-LeMoyne, É. (2014). Precision is in the Eye of the Beholder: Application of Eye Fixation-Related Potentials to Information Systems Research. *Journal of the Association for Information Systems* (15:10), Article 3.
- Pfeiffer, J., Meißner, M., Brandstätter, E., Riedl, R., Decker, R., Rothlauf, F. (2014). On the influence of context-based complexity on information search patterns: An individual perspective. *Journal of Neuroscience, Psychology, and Economics* (7:2), 103-124.

9. HOW TO USE FACIAL MUSCULAR MOVEMENT IN NEUROIS STUDIES?

Overview

This unit gives an overview of technologies available to record facial muscular movement to infer human emotion. The two main methods for measuring facial expression are the placement of electromyography (EMG) sensors on the face of a subject and the use of automatic facial analysis based on software programs. The unit discusses how these methods work, their benefits and limitations, and selected experimental designs and statistical techniques. The unit also reviews how Facial Muscular Movement has contributed to IS research.

Learning Outcomes

After the unit participants are able to
- Describe how facial muscular movement can be measured and used to infer basic emotions
- Discuss the benefits and limitations of this tool in IS research
- Describe experimental designs and statistical techniques used within the Facial Muscular Movement domain

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 3 (Tools in NeuroIS Research: An Overview)
- Mandryk, R. L., Atkins, S. M. (2007). A fuzzy physiological approach for continuously modeling emotion during interaction with play technologies. *International Journal of Human-Computer Studies* (65), 329-347.
- Georges, V., Courtemanche, F., Sénécal, S., Baccino, T., Léger, P.-M., Fredette, M. (2015). Measuring Visual Complexity Using Neurophysiological Data. In: F.D. Davis et al. (eds.), Information Systems and Neuroscience, Lecture Notes in Information Systems and Organisation 10 (pp. 9-17), Springer.
- Minas, R. K., Potter, R. F., Dennis, A. R., Bartelt, V., Bae, S. (2014). Putting on the Thinking Cap: Using NeuroIS to Understand Information Processing Biases in Virtual Teams. *Journal of Management Information Systems* (30:4), 49-82.

10. HOW TO USE HORMONE MEASUREMENT IN NEUROIS STUDIES?

Overview

This unit gives an overview of how hormones can inform IS research and how to measure them. From an IS perspective, it is important to understand that many hormones have significant behavioral relevance (e.g., in stress or trust situations). The unit discusses how hormones act in the body, how hormone measurement works, the benefits and limitations of this method, and selected experimental designs and statistical techniques. The unit also reviews how hormone measures have contributed to IS research.

Learning Outcomes

After the unit participants are able to

- Describe how hormones can be measured
- Discuss the benefits and limitations of this method in IS research
- Describe experimental designs and statistical techniques used within the hormone measurement domain

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 3 (Tools in NeuroIS Research: An Overview)
- Riedl, R., Kindermann, H., Auinger, A., Javor, A. (2012). Technostress from a neurobiological perspective: System breakdown increases the stress hormone cortisol in computer users. *Business & Information Systems Engineering* (4:2), 61-69.
- Tams, S. Hill, K., Ortiz de Guinea, A., Thatcher, J., and Grover, V. (2014). NeuroIS—Alternative or Complement to Existing Methods? Illustrating the Holistic Effects of Neuroscience and Self-Reported Data in the Context of Technostress Research. *Journal of the Association for Information Systems* (15:10), Article 1.
- Javor, A., Riedl, R., Kindermann, H., Brandstätter, W., Ransmayr, G., Gabriel, M. (2014). Correlation of plasma and salivary oxytocin in healthy young men – Experimental evidence. *Neuroendocrinology Letters* (35:6), 470-473.
- Riedl, R. (2013). On the Biology of Technostress: Literature Review and Research Agenda. DATA BASE for Advances in Information Systems (44:1), 18-55.
- Riedl, R., Javor, A. (2012). The biology of trust: Integrating evidence from genetics, endocrinology and functional brain imaging. *Journal of Neuroscience, Psychology, and Economics* (5:2), 63-91.

11. HOW TO ESTABLISH A NEUROIS LAB?

Overview

This unit gives practical recommendations on how to establish and operate a NeuroIS lab. The unit provides recommendations on the setting of the experimental rooms, measurement equipment, software, and consumables. The unit discusses sources of information where IS researchers could learn about neurophysiological measurement instruments and establish contacts with vendors of such instruments.

Learning Outcomes

After the unit participants are able to

- Provide an overview of important issues related to the establishment and operation of a NeuroIS laboratory

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer, Chapter 5 (Establishing and Operating a NeuroIS Lab).

12. DISCUSSION OF STUDENTS' NEUROIS RESEARCH PROPOSALS

Overview

This unit provides the opportunity to discuss students' NeuroIS research proposals with the lecturers. To this end, students have to develop research proposals in which they describe the idea for a NeuroIS study. The proposals should be organized along the following structure: problem statement, research questions and/or hypotheses, methods (data acquisition and data analysis), contribution to the IS literature, theoretical and practical implications.

Learning Outcomes

After the unit participants are able to

- Develop, present, and discuss a NeuroIS research proposal

Material

- Riedl, R., Léger, P.-M. (2016). *Fundamentals of NeuroIS: Information Systems and the Brain*, Springer.
- Riedl, R., Davis, F. D., Hevner, A. R. (2014). Towards a NeuroIS Research Methodology: Intensifying the Discussion on Methods, Tools, and Measurement. *Journal of the Association for Information Systems* (15:10), Article 4.
- Vom Brocke, J., Liang, T.-P. (2014). Guidelines for Neuroscience Studies in Information Systems Research. *Journal of Management Information Systems* (30:4), 211-234.

Note

Since 2009 an annual academic conference for presenting research and development projects at the nexus of IS and neurobiology is organized, the *Gmunden Retreat on NeuroIS* (www.NeuroIS.org). This annual event takes place in Gmunden, Austria, and it has the objective to promote the successful development of the NeuroIS field. In the context of this conference, a **NeuroIS training course** is organized every year (typically as a one-day pre-event of the main conference). This course is designed to give participants a basic foundation in major concepts, methods, and tools related to NeuroIS research.

Recommended Citation

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