NeuroIS: A Survey on the Status of the Field

Thomas Fischer, Fred D. Davis and René Riedl

Abstract NeuroIS has emerged as a research field in the Information Systems (IS) discipline over the past decade. Since the inaugural NeuroIS Retreat in 2009, 166 individuals participated at this annual academic conference to discuss research and development projects at the nexus of IS and neuroscience research. Motivated by the fact that the NeuroIS Retreat celebrates its 10-year anniversary in 2018, we invited all 166 former participants of the NeuroIS Retreat to state their opinions in an online survey on the development of the field and its future. In this paper, we summarize the answers of N = 60 respondents regarding NeuroIS topics and methods.

Keywords Brain · Methods · NeuroIS · Status · Survey · Tools · Topics

1 Introduction

The first NeuroIS Retreat took place in Gmunden, Austria, in 2009. Since then, the NeuroIS community has grown and in 2018 this annual academic conference celebrates the 10 years anniversary in Vienna, Austria. A total of 166 individuals attended this forum for the presentation and discussion of research and development projects in the last decade, and thereby contributed to the prosperous development of the field. Motivated by the fact that the NeuroIS Retreat exists for 10 years now, we developed an online survey to ask all former conference participants about their

T. Fischer (✉) · R. Riedl
University of Applied Sciences Upper Austria, Steyr, Austria
e-mail: thomas.fischer@fh-steyr.at

R. Riedl
e-mail: rene.riedl@fh-steyr.at

F. D. Davis
Texas Tech University, Lubbock, USA
e-mail: fred.davis@ttu.edu

R. Riedl
Johannes Kepler University, Linz, Austria

F. D. Davis et al. (eds.), *Information Systems and Neuroscience*,
Lecture Notes in Information Systems and Organisation 29,
https://doi.org/10.1007/978-3-030-01087-4_1

perspectives on the status of the field. In this paper, we present major results of this survey related to NeuroIS topics and methods. Specifically, we investigated the participants' perspectives on topics and methods, which are currently studied and applied, and what they think about future topics and methods.

2 Survey Characteristics and Sample Demographics

Using the online survey tool SoSci Survey, we conducted a survey amongst a population of all 166 previous participants of the NeuroIS Retreat 2009–2017 in the period 12/04/2017–02/06/2018. The survey contained questions related to impressions of the past developments in the field, but also gave respondents the opportunity to report on their future NeuroIS research and their expectations for the field. Overall, it took about ten minutes to complete the survey. We were able to gather 60 complete responses, amongst 152 individuals who are still involved in academic research (response rate of 39.5%). The remaining 14 individuals are not active researchers anymore and it was not possible to contact them in the context of this study.

Amongst the respondents, 75% were male and a majority of 64% is between 30 and 49 years old (see Fig. 1). We also asked respondents to indicate the country were they are currently employed (see Fig. 2). The results show that most respondents are currently either employed in German-speaking countries (25 individuals are from Austria, Germany, Switzerland, and Liechtenstein) or North America (24 individuals are from the USA and Canada).

We also wanted to know the current academic position of our respondents, which revealed that 39% were full professors, followed by 19% who were Ph.D. candidates and 17% each who were either associate professor or assistant professor. This finding indicates that the field is not only interesting to a selected group of established researchers, but also allows new researchers to enter the arena, such as early-stage

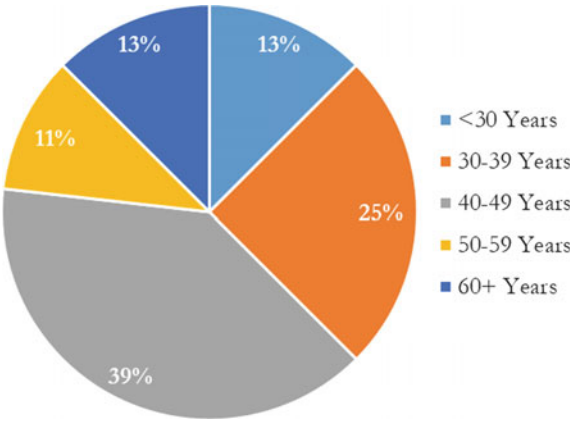


Fig. 1 Share of respondents per age group (N = 60)

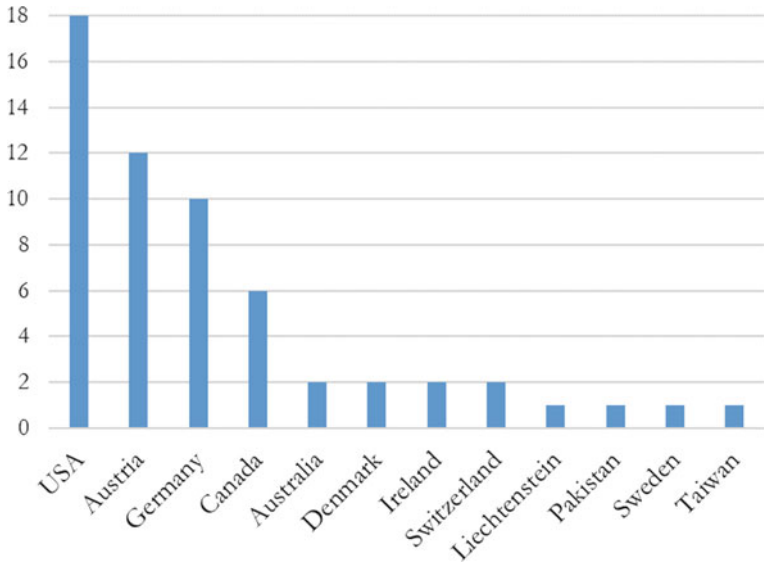


Fig. 2 Number of respondents per country of employment (N = 60)

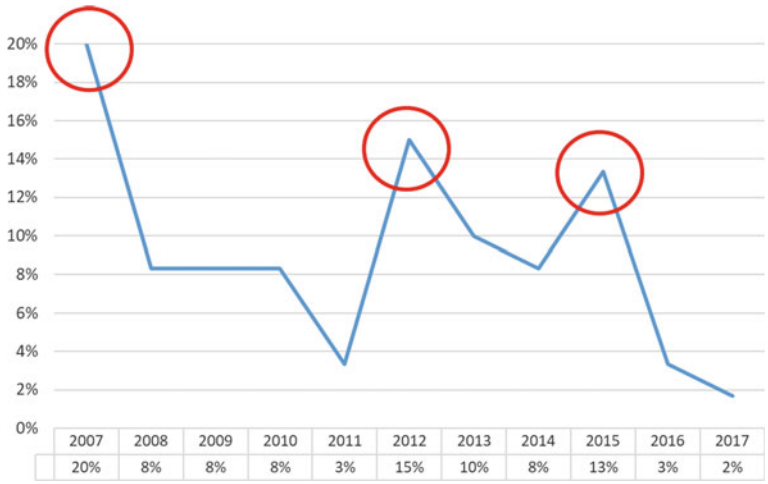


Fig. 3 Share of respondents per year in which they first came into contact with NeuroIS (N = 60)

researchers. This finding is substantiated by the fact that only 20% of our respondents are affiliated with NeuroIS since its establishment in 2007; there is a substantial number of researchers who entered the field later (e.g., 2012 and 2015, see Fig. 3).

Most of these individuals (85%) came into touch with NeuroIS through personal contacts (e.g., Ph.D. students through their professors who had previously attended the NeuroIS Retreat), but also NeuroIS publications were an important source of

information (28%). The website www.NeuroIS.org and conference calls were also of some importance (point of contact for 13% of respondents each), but not comparable to word-of-mouth spread throughout the NeuroIS community and related communities such as the more general IS community.

3 Topics

We asked respondents about the NeuroIS topics on which they had focused in their previous research and the topics they think were most important in NeuroIS research in the past decade. As our respondents had the possibility to indicate more than one topic (or construct), we ended up with a list of more than 40 different NeuroIS topics. Here we report the topics which were mentioned by at least 10% of our respondents as a current or future focus in their research or as being amongst the most important NeuroIS topics in the past decade. Through some abstractions (e.g., grouping "emotional responses" and "affective processing" into the category "Emotions"), we ended up with eight main topics (see Fig. 4).

We first looked at the current and future focus in the research of our respondents (see the blue and orange bars in Fig. 4) and found that topics which are established in neuroscience (or related fields such as neuropsychology or neuroergonomics) such as cognitive load, emotions, and stress, are also amongst the most popular topics in NeuroIS research. As shown in Fig. 4, it can be expected that there will be a stronger focus on emotion in future research. In the case of other popular topics (e.g., technology acceptance or trust), our respondents were not so certain whether they will still focus on these topics in their future research. These findings are also in line with a recent review, which showed that cognitive and emotional processes

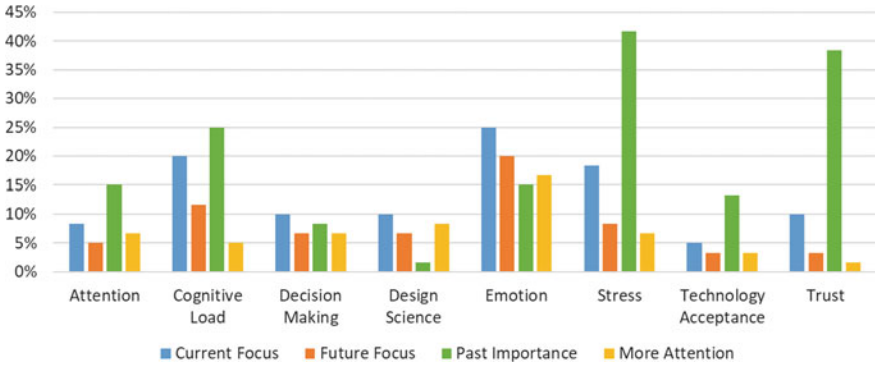


Fig. 4 NeuroIS topics with share of respondents who currently focus on them (blue bar) and will focus on them in the future (orange bar), importance of the topic in the past decade (green bar) and calls for more attention in future research (yellow bar) (N = 60)

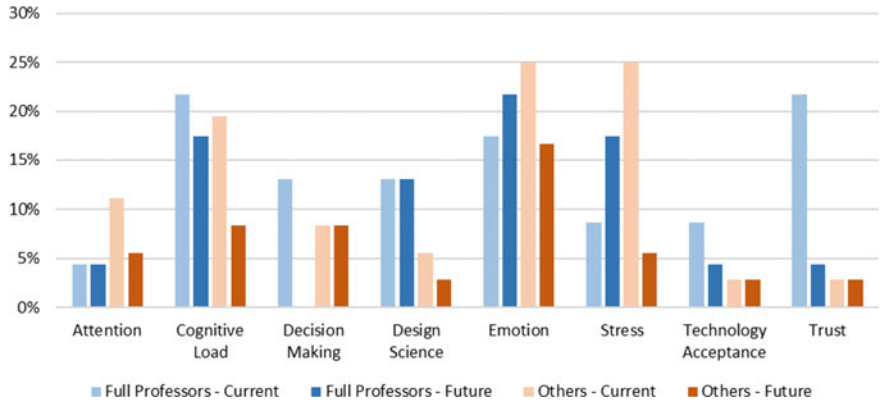


Fig. 5 NeuroIS topics with share of full professors who currently focus on them (light blue bar) and will focus on them in the future (dark blue bar), and researchers with a different tenure status who currently focus on them (light red bar) and will focus on them in the future (dark red bar) (N = 59)

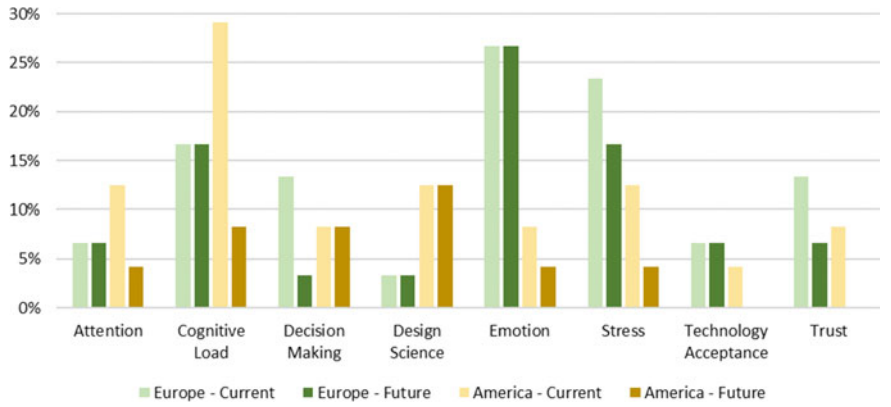


Fig. 6 NeuroIS topics with share of respondents from Europe who currently focus on them (light green bar) and will focus on them in the future (dark green bar), and researchers from North America who currently focus on them (light yellow bar) and will focus on them in the future (dark yellow bar) (N = 54)

have been the main focus in the extant NeuroIS literature, while decision-making processes and social processes were of lower importance [1].

In addition, we asked the respondents to indicate the topics that they felt had been the most important ones in the first decade of NeuroIS research (green bars, Fig. 4) and whether these topics should receive more attention (yellow bars, Fig. 4). Interestingly, emotion is not amongst the top 3 of the most important topics. Instead, most respondents felt that trust was amongst the most important topics, in addition to stress and cognitive load. This result is plausible because early NeuroIS publications in top IS journals had a focus on trust, such as [2]. Still, emotion as a topic received the

most votes (i.e., 17%) when it came to the topics that should receive more attention in future research.

We further analyzed the topics that respondents focus on in their current and will focus on in their future research, based on two respondent characteristics, namely their tenure status and their country of employment, grouped into continents. For the tenure status, we looked at the differences between full professors (39% of our respondents) and the remaining respondents. For the country of employment, we looked at differences between researchers from Europe (50% of our respondents) and North America (40% of our respondents).

Regarding the current and future research topics of full professors, we found noteworthy differences (see Fig. 5). In general, most respondents who are currently not full professors are uncertain about the topics on which they will focus in their future research (which can, for example, be explained by the uncertainty of the future funding of their research). Full professors rather than the remaining respondents indicated that they will focus more strongly on emotions, as well as stress, in their future research, while decision-making and trust are topics of lower interest. For most other topics (e.g., attention, cognitive load, or design science) we observe equal interest by full professors in the future.

We also found differences regarding the thematic focus of researchers from Europe and North America (Fig. 6). While emotions and stress are more prevalent topics for European researchers, particularly design science is a topic that is more prevalent in the research of American researchers (note that design science, as defined in our research context, does not necessarily imply systems engineering activities, which are often typical for researchers from German-speaking countries, [3]). There will also likely be some shifts in the thematic focus, with European researchers focusing more strongly on attention and cognitive load research in the future, while American researchers will likely more strongly focus on decision-making.

4 Methods

We also asked the respondents about data collection methods they had previously used in their NeuroIS research, which methods they may use in the future, and whether they thought that certain methods should receive more or less attention in future NeuroIS research. We included a total of 13 data collection methods in our survey (i.e., blood pressure, heart rate related-measures, eyetracking, EMG, EEG, fMRI, NIRS, skin conductance-related measures, hormone measures based on blood, urine, or saliva, neurological patients, and transcranial direct current stimulation). In Figs. 7 and 8, we have summarized the results for each of these methods regarding (1) how many respondents have used them before ("previous use", blue bar), and (2) how those respondents who did not use a method before, intend to use it in the future ("intended use", orange bar; e.g., 20% of the respondents used hormone measures from saliva before and an additional 20% intend to use it in the future). In the case of previously used methods, eyetracking is on top with 58% of respondents

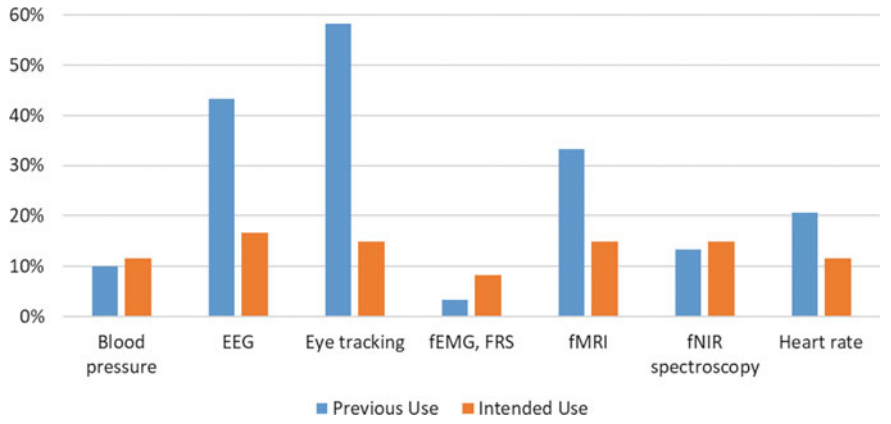


Fig. 7 NeuroIS methods with share of respondents who have previously used them (blue bar) and intent to use them in the future amongst previous non-users (orange bar) (N = 60), Part 1

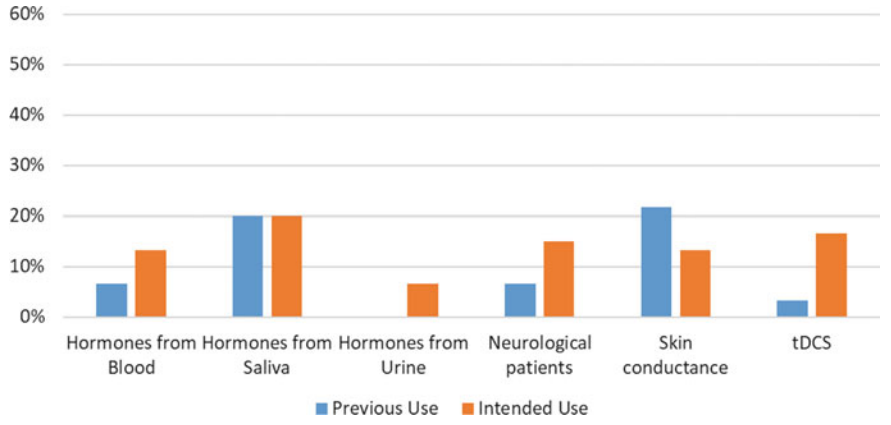
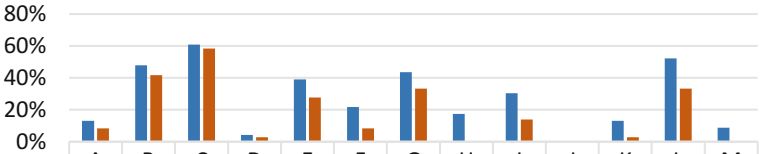


Fig. 8 NeuroIS methods with share of respondents who have previously used them and intent to use them in the future amongst previous non-users (N = 60), Part 2

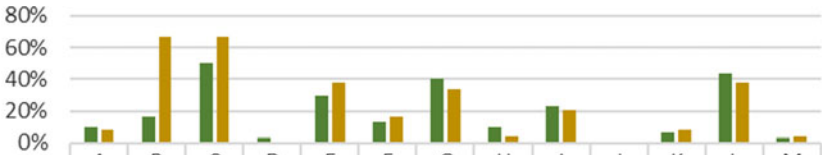
indicating that they had used this method in their research. For intended use, hormone measurements based on saliva are in the lead, with 20% of respondents indicating that they would like to use this method in their future research (see Fig. 7).

In addition to eyetracking, which is widely employed and will also likely receive further attention in the future, particularly measures that collect data related to processes of the central nervous system (i.e., EEG, fMRI, NIRS, tDCS, and to some extent neurological patients) will be part of the future research of our respondents. It is interesting to see though, that saliva measurements may become more popular in the future as they can, for example, be used to measure physiological stress based on alpha amylase levels as indicator (e.g., [4]). Because the use of saliva samples, if compared to central nervous system measurements, implies less research effort and



	A	B	C	D	E	F	G	H	I	J	K	L	M
Full Professors	13%	48%	61%	4%	39%	22%	43%	17%	30%	0%	13%	52%	9%
Others	8%	42%	58%	3%	28%	8%	33%	0%	14%	0%	3%	33%	0%

Fig. 9 NeuroIS methods with share of respondents with full professor status who have previously used them (dark blue bar) and share of respondents with other tenure status who previously used them (dark orange bar) (N = 59). Legend: (A) blood pressure, (B) EEG, (C) Eyetracking, (D) fEMG, (E) fMRI, (F) fNIRS, (G) HR, (H) Hormones from Blood, (I) Hormones from Saliva, (J) Hormones from Urine, (K) Neurological Patients, (L) Skin Conductance, (M) tDCS



	A	B	C	D	E	F	G	H	I	J	K	L	M
Europe	10%	17%	50%	3%	30%	13%	40%	10%	23%	0%	7%	43%	3%
America	8%	67%	67%	0%	38%	17%	33%	4%	21%	0%	8%	38%	4%

Fig. 10 NeuroIS methods with share of respondents from Europe who have previously used them (dark green bar) and share of respondents from North America who previously used them (dark yellow bar) (N = 54). Legend: (A) blood pressure, (B) EEG, (C) Eyetracking, (D) fEMG, (E) fMRI, (F) fNIRS, (G) HR, (H) Hormones from Blood, (I) Hormones from Saliva, (J) Hormones from Urine, (K) Neurological Patients, (L) Skin Conductance, (M) tDCS

causes lower costs, it seems that many NeuroIS researchers base their research tool selection on pragmatic reasons. Why the intended use of measurements related to autonomic nervous system activity (e.g., heart rate, skin conductance) is rather low in our sample (despite its enormous potential in IS research, see [5]) remains an open question that deserves further investigation.

Some respondents also mentioned additional methods that should be of importance in future NeuroIS research including voxel-based morphometry (VBM), Magnetoencephalography (MEG), genetic measures, measurements made using data from everyday devices (e.g., smartwatches, see [6]), combinations of methods (e.g., eyetracking and fMRI, see [7]) and behavioral measures such as mouse cursor tracking.

In Figs. 9 and 10, we provide an overview of the differences concerning the previous use of NeuroIS methods among our respondents based on tenure status (Fig. 9) and country of employment (Fig. 10).

Based on tenure status, we hardly find differences, though the share of full professors who have used fNIRS (F), hormones from blood (H) or saliva (I), as well as neurological patients (K), in their research is considerably larger than the share of respondents with other tenure status. This could, for example, be explained by the complexity of getting access to the involved materials and data (e.g., in the case of hormones and neurological patients) or the novelty and cost of research methods (e.g., fNIRS), which makes access to these methods harder for individuals with lower tenure status.

We also analyzed differences in previous method use based on the country of employment, again clustered by continent (Fig. 10). We find tendencies for European researchers to more frequently employ methods that can be used to measure the activity of the autonomic nervous system (e.g., (G) heart rate or (L) skin conductance), while North American researchers more frequently employ methods that can be used to measure the activity of the central nervous system (e.g., (B) EEG or (E) fMRI). The largest differences can be found for (B) EEG and (C) Eyetracking, which are more frequently used by North American researchers. Future research must determine the reasons for the observed differences.

5 Conclusion

Based on an online survey among N = 60 former participants of the NeuroIS Retreat, we found that emotional processes will likely be a key topic, eventually *the* key topic, in future NeuroIS research. Methodologically, we found that eyetracking measures and brain-related measures such as EEG or fMRI will be of high relevance in the future. These findings are in line with observations in the NeuroIS literature, as emotional processes have been of major importance in previous NeuroIS research [1], and NeuroIS publications in the most prestigious IS journals have often applied brain-related measures such as fMRI (e.g., [2, 8–12]). Importantly, our survey also revealed the interest of NeuroIS researchers in methods which have not been used frequently thus far, such as EMG and FRS (Face Recognition Software, e.g. to determine user emotion, for details see [13]). It seems that NeuroIS researchers have realized that these and further methods are well suited to reveal insights into the NeuroIS topics of the future (e.g., [14]).

Acknowledgements This research was funded by the Upper Austrian government as part of the Ph.D. program "Digital Business International", a joint initiative between the University of Applied Sciences Upper Austria and the University of Linz.

References

1. Riedl, R., Fischer, T., Léger, P.-M.: A decade of NeuroIS research: status quo, challenges, and future directions. In: Kim, Y.J., Agarwal, R., Lee, J.K. (eds.) Proceedings of the Thirty Eighth International Conference on Information Systems (2017)
2. Dimoka, A.: What does the brain tell us about trust and distrust? Evidence from a functional neuroimaging study. MIS Q. **34**, 373–396 (2010)
3. Heinrich, L.J., Riedl, R.: Understanding the dominance and advocacy of the design-oriented research approach in the business informatics community: a history-based examination. J. Inf. Technol. **28**, 34–49 (2013)
4. Tams, S., Hill, K., Ortiz de Guinea, A., Thatcher, J., Grover, V.: NeuroIS—alternative or complement to existing methods? Illustrating the holistic effects of neuroscience and self-reported data in the context of technostress research. J. Assoc. Inf. Syst. **15**, 723–753 (2014)
5. Riedl, R., Davis, F.D., Hevner, A.: Towards a NeuroIS research methodology: intensifying the discussion on methods, tools, and measurement. J. Assoc. Inf. Syst. **15**, i–xxxv (2014)
6. Fischer, T., Riedl, R.: Lifelogging as a viable data source for NeuroIS researchers: a review of neurophysiological data types collected in the lifelogging literature. In: Davis, F.D., Riedl, R., Vom Brocke, J., Léger, P.-M., Randolph, A.B. (eds.) Information Systems and Neuroscience. Gmunden Retreat on NeuroIS, pp. 165–174. Springer, New York (2016)
7. Vance, A., Jenkins, J.L., Anderson, B.B., Bjornn, D.K., Kirwan, C.B.: Tuning out security warnings: a longitudinal examination of habituation through fMRI, eye tracking, and field experiments (forthcoming) (2018)
8. Riedl, R., Hubert, M., Kenning, P.H.: Are there neural gender differences in online trust? An fMRI study on the perceived trustworthiness of eBay offers. MIS Q. **34**, 397–428 (2010)
9. Anderson, B.B., Vance, A., Kirwan, C.B., Jenkins, J.L., Eargle, D.: From warning to wallpaper: why the brain habituates to security warnings and what can be done about it. J. Manage. Inf. Syst. **33**, 713–743 (2016)
10. Jenkins, J.L., Anderson, B.B., Vance, A., Kirwan, C.B., Eargle, D.: More harm than good? How Messages that interrupt can make us vulnerable. Inf. Syst. Res. **27**, 880–896 (2016)
11. Riedl, R., Mohr, P.N.C., Kenning, P.H., Davis, F.D., Heekeren, H.R.: Trusting humans and avatars: a brain imaging study based on evolution theory. J. Manage. Inf. Syst. **30**, 83–114 (2014)
12. Warkentin, M., Walden, E.A., Johnston, A.C., Straub, D.W.: Neural correlates of protection motivation for secure IT behaviors: an fMRI examination. J. Assoc. Inf. Syst. **17**, 194–215 (2016)
13. Riedl, R., Léger, P.-M.: Fundamentals of NeuroIS: Information Systems and the Brain. Springer, Berlin (2016)
14. Koller, M., Walla, P.: Measuring affective information processing in information systems and consumer research—introducing startle reflex modulation. In: George, J.F. (ed.) Proceedings of the 33rd International Conference on Information Systems (2012)