Proceedings
Gmunden Retreat on NeuroIS 2014

Gmunden, Austria | June 5-7, 2014 | www.NeuroIS.org

Fred Davis, René Riedl, Jan vom Brocke,
Pierre-Majorique Léger, Adriane Randolph
(Eds.)

Presentations

Gmunden Retreat on NeuroIS 2014

Designing Web Pages for Increased Content Familiarity: A Strategy 1 Study

Rob Gleasure, Department of Accounting, Finance, and Information Systems, University College Cork, Ireland

r.gleasure@ucc.ie

There are numerous motivations for small-to-medium businesses to engage in ecommerce (Grandon and Pearson 2004, O'Reilly 2007). Yet in order for these businesses to generate value from their ecommerce activities, it is important that they can foster a sense of familiarity among users with the content of their websites (Gefen 2003). Thus, the objective of this study is to identify some design mechanism for websites that allows for increased content familiarity.

The concept of familiarity is one that has received significant attention in the field of neuroscience, particularly with regard to its differentiation from other forms of memory (Haist et al. 1992; McLaren et al. 2013). This perspective typically divides memory into 'recollection', in which objects are brought to mind in relation to some cue, and 'familiarity', in which objects are perceived as familiar only once they are presented (Ochsner 2000; Buckner and Wheeler 2001; Norman and O'Reilly 2003). This distinction is supported by findings that different neurophysiological regions are responsible for each (Allan et al. 1998; Mayes et al. 2007; Rugg and Yonelinas 2003). Most notably, a range of findings suggest that the perirhinal cortex and anterior parahippocampal regions within the medial temporal lobe (MTL) are key areas for familiarity-based recognition, while the hippocampus and posterior parahippocampal regions are key areas for recollection (c.f. Yonelinas 2002).

An important component of these memory systems is the 'emotion modulation' of memory formation, which suggests that more emotive stimuli are encoded more effectively due to relationships between affective regions of the brain and memory-related areas in both the MTL (McGaugh 2000) and in sensory cortices (Hofstetter et al. 2012). Yet there have been suggestions that different networks are involved in the processing of positive and negatively affective stimuli, e.g. with the amygdala playing a more central role for negatively affective stimuli (Aldhafeeri et al. 2012; Kensinger 2004). This suggests that positively and negatively affective stimuli may affect different memory functions in different ways (Kensinger and Schacter 2007).

As one may expect, this moderating effect of emotional valence on memory is also associated with attentional differences, whereby negatively valenced content encourages attention on some specific details of scenes while positive valenced content encourages attention on more holistic aspects (Gasper and Clore 2002). This was illustrated by recent observations of faster response times in search tasks with positively valenced image distractors and slower response times in tasks with negatively valenced distractors (Sussman et al. 2013). Thus, in a web design context, ancillary images with positive valence may potentially increase the familiarity of core content. Yet the perirhinal cortex and anterior parahippocampal areas of the MTL are known to be especially sensitive to repetition suppression, whereby neural responses decrease following continuous exposure to the same stimuli (Gonsalves et al. 2005; Ranganath and Rainer 2003). This suggests that the benefits of positively valenced images in web design may be diminished as those images become less novel to users.

Like emotional valence, arousal plays an important role in the modulation hypothesis, as demonstrated by the observation that amphetamines can enhance memorization (Soetens et al. 1995). This moderating effect exists for both positive and negatively valenced stimuli, yet the effect is significantly greater when valence is negative, (Kensinger 2004). Interestingly, like negatively-valenced content, high-arousal content also serves to narrow the attentional focus, as opposed to low-arousal content which broadens it (Gable and Harmon-Jones 2010). This relationship between attentional focus, negative valence, and arousal appears to surround a central role for the same brain regions in each, e.g. the amygdala, nucleus accumbens, and anterior cingulate cortex (Anderson et al. 2001; Pessoa 2008). Such a relationship means the effect of high-arousal images in web design may be to draw attention to the images themselves, rather than the core content of webpages.

Thus the design hypothesis is proposed in this study that *webpages should include novel low-arousal images of positive valence to increase users' familiarity with the content of that webpage.*

The choice of methods to test this design hypothesis was determined by two factors. Firstly, the extent of existing research on familiarity lends itself to a deductive approach. Secondly, the desired utility of these design principles are behavioral in nature. Hence, a strategy 1 approach was adopted, i.e. existing theory from neuroscience was used to inform design theorizing while behavioral measures were used to determine the resulting theory's utility (vom Brocke et al. 2013). To this end, a website was developed in the form of a web portal for third party massive open online courses (MOOCs). This web portal contained seven pages in total, including one homepage and six web pages dedicated to six specific categories of MOOCs. Images were placed in the center of the screen, above the main content of webpages, and below a logo for the fictitious website and a simple navigation bar. The images used were taken from the International Affective Picture System (IAPS), a standardized set of color photographs across a range of semantic categories, which are distributed to researchers upon request, along with quantitative ratings for valence, arousal, and dominance (Lang et al. 2008). The images that were used all possessed valence scores >6.5 on the negative-positive dimension, as well as scores on the arousal dimension of either <4.5 for low-arousal images or >6.5 for high-arousal images.

A 2x2x2 between-subjects factorial design was implemented to test the design hypothesis. The first factor represented image novelty, whereby the website either displayed the same image continuously across different webpages, or a novel image for each individual webpage. The second factor represented image arousal, whereby images displayed on the website were either high-arousal or low-arousal. The third factor represented the basic behavioral dynamics of the interaction. The focus of attention differs among search tasks and other visual behavior (Itti and Koch 2001), hence subjects were either (1) presented with six search tasks to find and select some specific course as quickly as possible, without being told in which category that course was located, or (2) to browse each category and select the course they found most interesting. Subjects were briefed that the purpose of the experiment was to evaluate some aspects of web design but were not made aware that familiarity or memory was the main focus of this investigation. This approach was taken to avoid giving subjects any knowledge that could compromise their ability to behave in a representative manner. Upon completion of the experiment, each subject was presented with 10 courses, 5 of which they had been exposed to in the original website and 5 of which had not. They were then asked to select the 5 courses they believed they had encountered.

131 subjects participated in the experiment as part of coursework for one undergraduate program and one postgraduate program. This included 77 males and 54 females with an average age of 23.67. The scores from the course recognition tests for these subjects were compared with a two-tailed analysis of variance, the results of which are illustrated in Table 1.

These results show two statistically significant relationships. The first of these is the interaction between whether the images used were alternating or constant, and whether the images used were low-arousal or high-arousal (see Figure 1). This interaction shows that subjects performed best on the familiarity test when their web pages contained novel low-arousal images, under which conditions they correctly identified an average of 3.406 courses. The absence of any interaction with browsing/searching conditions also suggests that this was unaffected by behavioral differences in the tasks set for users. Thus the design hypothesis put forward by this study is supported.

Table 1. Results for course recognition tests

	F	Sig.
Alternating/Constant	2.161	.245
High/Low Arousal	.055	.564
Browse/Search	26.025	<.001**
Alternating/Constant * High/Low Arousal	4.206	.044*
Alternating/Constant * Browse/Search	.034	.883
High/Low Arousal * Browse/Search	.657	.245
Alternating/Constant * High/Low Arousal * Browse/Search	.840	.314

* = p<0.05, ** = p<0.001

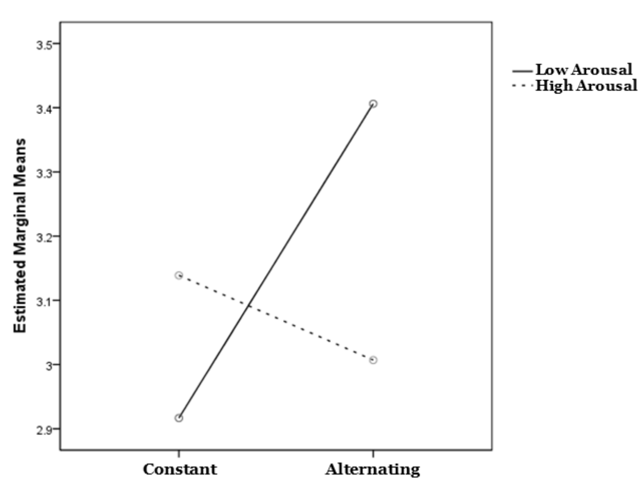


Figure 1. Interaction for content recognition between image-alternating and image arousal

The second statistically significant relationship was the main effect for the browsing/searching condition. The average subject correctly identified 3.09 courses, however this rose to 3.523 during browsing tasks and fell to 2.712 during search tasks. The existence of this difference is arguably not surprising, however the extent of the difference is interesting, as subjects in search tasks performed subsequent familiarity tests at a level close to that of pure chance. This suggests that individuals searching an ecommerce website for some specific item will gain familiarity with it far slower than those engaging in browsing behavior.

The findings from this study have implications for both neuroIS research and industrial web design. With regard to neuroIS, there are opportunities to expand upon the current research with more strategy 1 studies looking at other features of web design that contribute to users' emotional response and content familiarity, e.g. colors, sounds, animations, layouts, etc. There are also opportunities for strategy 2 research that seeks to identify biological correlates of the interplay between positively affective web design, arousal, and familiarity. Such research could then lay the foundation for strategy 3 research based on biofeedback mechanisms, e.g. facial recognition could be used to determine whether users are responding positively to images, eye-tracking could be used to determine attention and arousal, etc. The interface could then adapt to optimize interaction for any particular user, replacing ineffective images, adjusting contrast, etc. Lastly, there are opportunities to investigate the separate but related issue of content recollection in web design, which this study has not explored in detail. The interplay between these two facets of memorization, emotional valence, arousal, and different forms of web behavior, remain to be examined more closely at a neurophysiological level.

The implications for industrial web design are both direct and indirect. The direct implications concern the use of novel low-arousal imagery as a means of increasing content familiarity. The findings also suggest that websites should encourage browsing behavior in users where possible, rather than encouraging visits where users are looking for some pre-determined items. Indirect implications can be abstracted to a more mindful consideration by designers of the arousal-level of images and the goals of the website. Where the temptation may exist to increase the arousal of images to add excitement and catch users' attention (e.g. Lindgard et al. 2006), designers must maintain careful management of emotional valence if they are to effectively cultivate users' familiarity with content.

References

- Aldhafeeri, F. M., Mackenzie, I., Kay, T., Alghamdi, J., and Sluming, V. 2012. "Regional brain responses to pleasant and unpleasant IAPS pictures: different networks," *Neuroscience Letters* (152:2), pp. 94-98.
- Allan, K., L Wilding, E., and Rugg, M. D. 1998. "Electrophysiological evidence for dissociable processes contributing to recollection," *Acta Psychological* (98:2), pp. 231-252.
- Anderson, A. K., and Phelps, E. A. 2001. "Lesions of the human amygdala impair enhanced perception of emotionally salient events," *Nature* (411:6835), pp. 305-309.
- Gable, P., and Harmon-Jones, E. 2010. "The Blues Broaden, but the Nasty Narrows Attentional Consequences of Negative Affects Low and High in Motivational Intensity," *Psychological Science* (21:2), pp. 211-215.
- Gasper, K., and Clore, G. L. 2002. "Attending to the big picture: Mood and global versus local processing of visual information," *Psychological Science* (13:1), pp. 34-40.
- Gefen, D. 2000. "E-commerce: the role of familiarity and trust," *Omega* (28:6), pp. 725-737.
- Gonsalves, B. D., Kahn, I., Curran, T., Norman, K. A., and Wagner, A. D. 2005. "Memory strength and repetition suppression: multimodal imaging of medial temporal cortical contributions to recognition," *Neuron* (47:5), pp. 751-761.
- Grandon, E. E., and Pearson, J. M. 2004. "Electronic commerce adoption: an empirical study of small and medium US businesses," *Information & Management* (42:1), pp. 197-216.
- Haist, F., Shimamura, A. P., and Squire, L. R. 1992. "On the relationship between recall and recognition memory," *Journal of Experimental Psychology: Learning, Memory, and Cognition*, (*18:*4), pp. 691-712.
- Hofstetter, C., Achaibou, A., and Vuilleumier, P. 2012. "Reactivation of visual cortex during memory retrieval: content specificity and emotional modulation," *Neuroimage* (60:3), pp. 1734-1745.
- Itti, L., and Koch, C. 2001. "Computational modelling of visual attention," *Nature Reviews Neuroscience* (2:3), pp. 194-203.
- Kensinger, E. A. 2004. "Remembering emotional experiences: The contribution of valence and arousal," *Reviews in the Neurosciences* (15:4), pp. 241-252.
- Kensinger, E. A., and Schacter, D. L. 2006. "Amygdala activity is associated with the successful encoding of item, but not source, information for positive and negative stimuli," *The Journal of Neuroscience* (26:9), pp. 2564-2570
- Lang, P.J., Bradley, M.M., and Cuthbert, B.N. 2008. "International affective picture system (IAPS): Affective ratings of pictures and instruction manual," *Technical Report A-8*. University of Florida, Gainesville, FL.
- Lindgaard, G., Fernandes, G., Dudek, C., and Brown, J. 2006. "Attention web designers: You have 50 milliseconds to make a good first impression!," *Behaviour & Information Technology* (25:2), pp. 115-126.
- Mayes, A., Montaldi, D., and Migo, E. 2007. "Associative memory and the medial temporal lobes," *Trends in cognitive sciences* (11:3), pp. 126-135.
- McGaugh, J. L. 2000. "Memory-a century of consolidation. *Science* (287:5451), pp. 248-251.
- McLaren, I. P. L., Forrest, C. L. D., McLaren, R. P., Jones, F. W., Aitken, M. R. F., and Mackintosh, N. J. 2013. "Associations and propositions: The case for a dual-process account of learning in humans," *Neurobiology of Learning And Memory* (108), pp. 185-195.
- Norman, K. A., and O'Reilly, R. C. 2003. "Modeling hippocampal and neocortical contributions to recognition memory: a complementary-learning-systems approach," *Psychological Review* (110:4), pp. 611-646.
- O'Reilly, T. 2007. "What is Web 2.0: Design patterns and business models for the next generation of software," *Communications & Strategies*, (65:1), pp. 17-37.
- Ochsner, K. N. 2000. "Are affective events richly recollected or simply familiar? The experience and process of recognizing feelings past," *Journal of Experimental Psychology: General* (129:2), pp. 242-261.
- Pessoa, L. 2008. "On the relationship between emotion and cognition," *Nature Reviews Neuroscience* (9:2), pp. 148-158.
- Ranganath, C., and Rainer, G. 2003. "Neural mechanisms for detecting and remembering novel events," *Nature Reviews Neuroscience* (4:3), pp. 193-202.
- Rugg, M. D., and Yonelinas, A. P. 2003. "Human recognition memory: a cognitive neuroscience perspective," *Trends in Cognitive Sciences* (7:7) pp. 313-319.
- Soetens, E., Hueting, J. E., Casaer, S., and D'Hooge, R. 1995. "Effect of amphetamine on long-term retention of verbal material," *Psychopharmacology* (119:2), pp. 155-162.
- Sussman, T. J., Heller, W., Miller, G. A., and Mohanty, A. 2013. "Emotional distractors can enhance attention," *Psychological Science* (24:11), pp. 2322-2328.
- Vom Brocke, J., Riedl, R., and Léger, P. 2013. "Application strategies for neuroscience in information systems design science research," *Journal of Computer Information Systems* (53:3), pp 1-13.
- Yonelinas, A. P. 2002. "The nature of recollection and familiarity: A review of 30 years of research," *Journal of Memory and Language* (46:3), pp. 441-517.

Positive Emotions in IS

Anna-Maria Seeger, Tillmann Neben, and Armin Heinzl, University of Mannheim

Corresponding author: anseeger@mail.uni-mannheim.de

Negative emotions have received considerable attention in the Information Systems (IS) community. Studies on phenomena like technostress and information anxiety are two prominent examples. Positive emotions, however, have received less attention. Since they differ significantly from negative emotions in influencing human behavior, it is deemed appropriate to examine their nature and related effects. This research follows a two-step approach. First, we identify the *types* of positive emotion that are prevalent in IS research and explain how they can be differentiated *conceptually*. Second, we propose measures for distinguishing different types of positive emotion on a *psychophysiological* level.

Moods are long-lasting responses in the expressive and behavioral systems that are not directly related to specific stimuli. **Attitudes** signify long-lasting beliefs or preferences towards a subject or an object. **Emotions** are short-lived responses in the expressive, physiological and behavioral systems related to a specific stimulus. They involve changes in the *expressive*, *physiological* and *behavioral* systems. Past research developed three different models for differentiating emotions: discrete, dimensional and appraisal models (Lazarus 1991; Scherer 2000). We apply these models as a lens for identifying types of positive emotions that are relevant to IS research. In an initial round, we therefore reviewed the MIS Quarterly issues of the years 1979-2014. According to our analysis, *enjoyment* (Van der Heijden 2004; Venkatesh 1999) and *excitement* (Beaudry and Pinsonneault 2010) are the most often studied positive emotions with regard to information systems (cf. table 1).

These types of happiness emotions differ in their arousal, valence, and uncertainty properties. Based on the literature, we expect excitement to be associated with lower levels of positive valence than enjoyment (H1). Furthermore, we expect excitement to be associated with higher levels of arousal than enjoyment (H2). Finally, whereas enjoyment involves certainty about the positive event, excitement is related to *prospective* positive outcomes (Beaudry and Pinsonneault 2010) and, therefore, involves higher degrees of uncertainty (H3). In relation to the first goal of our study, enjoyment and excitement appear to represent distinct types of positive emotion on a *conceptual* level. In relation to our second goal, we seek to establish this difference on a *psychophysiological* level. In order to distinguish enjoyment from excitement, we plan to conduct the measurement of electrodermal activity (EDA), and the use of facial electromyography (EMG) in a controlled **experiment**. Participants perform a search task on a computer. Before the task begins, they are confronted with a gamble. Participants are informed that prizes are real and will be paid out. The *enjoyment* group wins 5€ and is immediately informed about the prize. The *excitement* group also wins, but is informed that they will learn later whether they won 5€ or a voucher for a coffee shop. This is to assure that the stimulus (winning the gamble) is of positive valence for both groups. Furthermore it allows to experimentally manipulate the level of *uncertainty*. EMG will be used to record zygomaticus major muscle activity as an indicator of positive valenced emotion. EDA recording over the sweat glands of the palm will be used as a measure of arousal. We see our hypotheses supported if EMG data indicates lower levels of zygomaticus major activity for the *excitement* condition (H1), and skin conductance responses (SCR) show higher amplitudes for the excitement condition (H2). In accordance with Wilson et al. (2005) we expect that the higher uncertainty of excitement translates into a prolonged duration of the emotion. Hence, we see H3 as supported, if the SCRs for the excitement condition persist over a longer time interval than for the enjoyment condition.

Table 1. Positive affect in MISQ (excerpt)

Period	Enjoyment or excitement	Other positive affect
1979-1989	-	1
1990-1999	1	2
2000-2009	4	4
2010-now	6	3
Total # of articles dealing with positive affect = 21		

References

- Beaudry, A., and Pinsonneault, A. 2010. “The other side of acceptance: studying the direct and indirect effects of emotions on information technology use,” MIS quarterly (34:4), pp. 689-710.
- Lazarus, R. S. 1991. Emotion and Adaptation, Oxford University Press, USA.
- Scherer, K. R. 2000. “Psychological models of emotion,” in The neuropsychology of emotion. Borod, Joan C., (ed.), New York: Oxford University Press, pp. 137-162.
- Van der Heijden, H. 2004. “User acceptance of hedonic information systems,” MIS quarterly (28:4), pp. 695–704.
- Venkatesh, V. 1999. “Creation of Favorable User Perceptions: Exploring the Role of Intrinsic Motivation.,” MIS quarterly (23:2), pp. 239–260.
- Wilson, T. D., Centerbar, D. B., Kermer, D. A., & Gilbert, D. T. 2005. „The Pleasures of Uncertainty: Prolonging Positive Moods in Ways People Do Not Anticipate,“ Journal of Personality and Social Psychology (88:1), pp. 5–21.

Using Neural Input to Control Google Glass

Adriane B. Randolph, Benjamin Warren, Stephen R. Krontz, and Joshua Z. Pate,
Kennesaw State University

Corresponding author: arandolph@kennesaw.edu

Over half a million people in the world who are living locked into their bodies may significantly improve their quality of life through the use of a mobile, non-invasive, brain-computer interface (BCI). Such a breakthrough has recently been made possible through the advanced release of Google Glass, a light-weight, head-mounted display (HMD) unit that contains its own computer processor and allows interactions similar to that of a smart phone (http://www.google.com/glass). The Kennesaw State University (KSU) BrainLab is working to pair neural input with Google Glass in the form of a non-traditional assistive technology (AT) device.

Assistive technology augments a person's functional capabilities. Traditional computer applications and AT devices require muscle movement for input, such as needed to manipulate a mouse and keyboard or a sip-and-puff switch. Brain-computer interfaces, a subset of Neuro-Information Systems, use neurophysiological inputs for non-muscularly controlled computer applications (Wolpaw, Birbaumer et al. 2002) and can therefore be considered non-traditional ATs.

Although they offer significant improvements to the quality of life for individuals with severe motor disabilities, BCIs have their challenges. These challenges range from considerations for the innate abilities of the user to capabilities of the technology, itself (Randolph and Moore Jackson 2010). In fact, interactions are often arduous in nature and mentally fatiguing for users, and the system cannot be fitted without extensive training by the caregiver who is often not a trained technician. To overcome these challenges, this work presents an approach for developing a mobile, light-weight BCI that can easily be fitted by a non-specialized caregiver.

Google Glass is a wearable technology that sits on the user's face. As needed, the user views a screen that is projected on a prism. To activate the interface, the user nods his/her head up or taps a touchpad located along the right side of the unit. He/she may then use touch, wink, or voice commands to interact with applications loaded on the system, conduct searches, take pictures and video, or scroll through saved content.

The director of the KSU BrainLab obtained a unit as one of 10,000 original Google Glass Explorers worldwide. She envisioned that someone with severe motor disabilities would be able to wear this light-weight device to access an assistive interface. Because Google Glass can be paired with an external mobile device, caregivers would have easy-access to support the user.

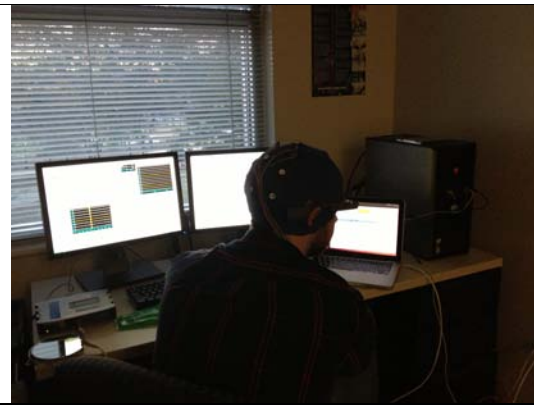


Figure 1. Researcher testing neural interface to Google Glass.

The KSU BrainLab has developed a working prototype that takes input from an evoked brain response to trigger the four basic interface commands for Google Glass: swipe left, swipe right, swipe down, and tap to select. Using open source software and a web interface, brain signals are recorded non-invasively and relayed through the computer to the Google Glass unit where the interface is displayed to the user. Currently, the user is presented with a string of characters from which he/she must select and attend to one. The characters flash in a randomized pattern. When the character the user desires flashes, he/she elicits a neural response approximately 300 milliseconds later, called a P300. This response is noted by the computer and a selection made. This interface is currently working with an artificially-generated brain signal.

The KSU BrainLab is in the process of testing with human participants and streamlining the interface design. The system will be significantly enhanced with a wireless design that allows greater mobility by users. Through the use of neural input to Google Glass, a person with severe motor disabilities may have continuous access to their non-traditional AT and achieve greater independence.

References

- Randolph, A. B. and M. M. Moore Jackson (2010). "Assessing Fit of Nontraditional Assistive Technologies." *ACM Transactions on Accessible Computing* 2(4): 1-31.
- Wolpaw, J. R., N. Birbaumer, et al. (2002). "Brain-Computer Interfaces for Communication and Control." *Clinical Neurophysiology* 113(6): 767-791.

Using transcranial Direct Current Stimulation (tDCS) to Assess the Role of the Dorsolateral Prefrontal Cortex in Technology Acceptance Decisions: A Pilot Study

Laurence Dumont[1,2], Félix Larochelle-Brunet[1,2], Hugo Théoret[2], Sylvain Sénécal[1], Pierre-Majorique Léger[1], René Riedl[3,4]
[1]Tech3Lab - HEC Montréal, [2]Psychology Department - Université de Montréal, [3]University of Applied Science Upper Austria, [4]University of Linz

Corresponding author: laurence.dumont.1@umontreal.ca

Introduction. Recent evidence suggests dissociation between important technology acceptance research constructs in the brain, specifically perceived ease of use (PEOU) and perceived usefulness (PU) (Dimoka et al. 2011). PEOU was reported to be linked to activity in the dorsolateral prefrontal cortex (DLPFC), a structure associated with cognitive effort and working memory, along with many other mental processes (Ridderinkhof et al., 2004). PU, in contrast, was associated to brain activity in the caudate nucleus, the insula, and the anterior cingulate cortex, three structures that do not reside in the frontal lobes of the brain, and which are therefore, at least theoretically, less likely involved in cognitive processing or deliberate reflective thought processes. Dimoka et al.'s (2011) descriptive study was a useful pilot study in revealing neural correlate candidates of technology acceptance constructs. Given the importance of technology acceptance studies in Information Systems (IS) research, further investigation is necessary (a) to validate these original results and (b) to draw causal inferences since Dimoka et al. used fMRI to study the neural correlates underlying technology acceptance decisions, making direct causal inferences impossible.

In this paper, we assess the role of the DLPFC in technology acceptance decisions by using transcranial Direct Current Stimulation (tDCS). This tool allows for modulation of the excitability of a precise cortical structure. tDCS has been used for almost 20 years in cognitive neuroscience research in order to pinpoint the particular role of different cortical structures and to treat some psychiatric disorders (Nitsche et al. 2009). Depending on the parameters of the stimulation, it can either increase or decrease the excitability of the targeted structure. A reliable placebo condition can also be implemented with this technique, enabling a valid control condition.

Background Literature. One of the major contributions of NeuroIS research is that implicit processes leading to the formation of beliefs and decisions can now be assessed in a different way if compared to traditional IS research, where scholars often solely relied on the explicit report of the users (Riedl et al. 2010). For instance, Ortiz de Guinea et al. (2013) showed that implicit and explicit measures of PEOU (and PU) interact in a non-linear fashion. Thus, it is unlikely that the DLPFC's activation exclusively and predictably influences explicit measures PEOU. In addition, given the known functions of the DLPFC (e.g., spatial information processing and motor planning; see Hoshi (2006) for a review), it is more likely that this structure plays a role in the implicit aspects preceding the explicit report of PEOU. In order to assess how this transition from implicit to explicit occurs, influencing the plausible implicit precursors to the explicit measures is important. Specifically, to test the relationship between PEOU and DLPFC, prior research has used fMRI data and a website evaluation task (Dimoka et al. 2011, pp. 695-698). However, in order to ascertain this relationship with greater validity, data with higher temporal resolution (e.g., EEG instead of fMRI) is needed, ideally based on actual online shopping purchase decisions. Moreover, the causal impact of brain stimulation (i.e., tDCS) on DLPFC excitability allows a more reliable assessment of the functional role of this brain structure in technology acceptance decisions.

Generally, by DLPFC stimulation, we sought to determine whether this structure plays an important role in human interaction with computer interfaces. We expect that the participants' explicit statements about PEOU of a computer system will be altered, either positively or negatively, as a function of DLPFC excitability (which we either increased or decreased through tDCS). Considering the previous findings reported in Dimoka et al. (2011), we hypothesize that in a condition where the left DLPFC's excitability is decreased, a user's rating of PEOU should be lower, if compared to control conditions. Moreover, considering the results of Dimoka et al., PEOU should decrease to a larger extent than PU when DLPFC is manipulated.

Method. Our approach relies on finding the impact of a structure's activation on different aspects of a task, instead of going the other way around (i.e., trying to find which structures are involved in an aspect of a task). The tDCS system, shown in Figure 1, consists of two electrodes linked to a specially designed case. This case delivers a small and controlled amount of electric current (1.5 mA in our case) between the two electrodes. In order for current to be safely delivered to the skull, the electrodes are inserted in small sponge sleeves soaked in saline. When applied on the skull, the current passes through the cerebral structures in between the two electrodes, mostly following in the nerve fibers between them (Sparing & Mottaghy 2008). Hence, a bilateral stimulation of the DLPFC, for example, would require that an electrode is placed on each DLPFC and depending on the direction of the current, either the right cortex's excitability is increased and the left ones decreased, or the left cortex's excitability is increased and the right ones decreased. Except for a tingling or itching sensation at the stimulation site on the scalp, no other major adverse effect is observed when standard safety procedures are followed.

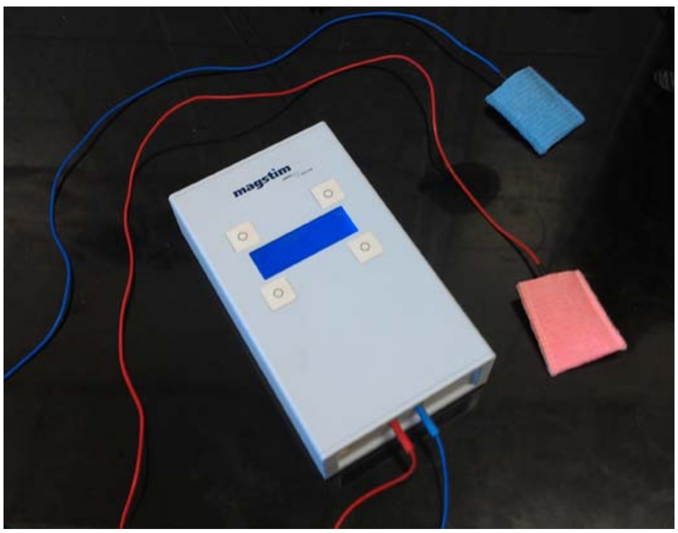


Figure 1. Magstim tDCS device

In order to test the relationship between PEOU and DLPFC we performed a laboratory experiment. The study was approved by the research board of the Université de Montréal. Participants were given information about tDCS before the experimental session took place and only those who were completely comfortable with the procedure took part in the experiment. Special attention was given to the participant's reaction to tDCS and the research assistants emphasized the possibility to terminate the experiment at any time. However, no participant reported discomfort important enough for them to stop the procedure. tDCS typically induces a warm tingling sensation on the sites of stimulation for about 30 seconds at the beginning and the end of the procedure.

A Magstim DC stimulator (London, UK) was used to deliver the tDCS stimulation for 15 minutes at 1,5 mA. The electrodes were placed on the left and right DLPFC, corresponding to the F3 and F4 sites of the 10-20 system. During the task, eye movements were also recorded using a Tobii X60 system. Moreover, heart rate, respiration, and skin conductance were recorded using Biopac instruments. Cerebral activity was recorded at all times except during the stimulation using EGI 32 electrodes nets.

Participants had to purchase music on a given website over multiple visits. The experimental protocol is illustrated in Figure 2 and described in the following. In the specific context of purchasing music online, Sénécal et al. (2012) showed that at least three visits are necessary to be cognitively locked-in to a music website; i.e., when a user's cognitive load has stabilized. Given the known impact of tDCS on learning (Fritsch et al., 2010), tDCS was used once this stabilization of the behavior was established.

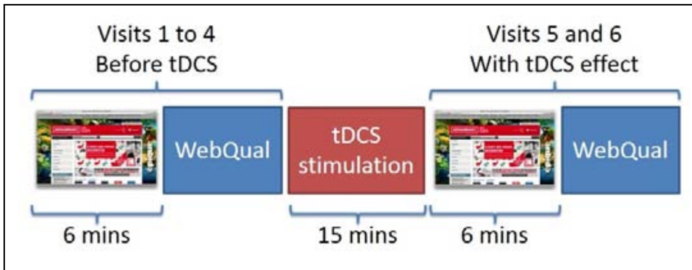


Figure 2. Experimental protocol

Based on Dimoka et al.'s (2011) and Senecal et al.'s (2012) findings, once the user has a stable cognitive script to use a given system (in our case a website), manipulating the brain structure that presumably underlies PEOU should influence the user's perception of the system, and maybe even affect his or her behavior with that system. By keeping the stimulus constant and altering the excitability of the DLPFC, it is possible to understand the causal role of this structure in a user's interaction with the system, and also interactions between PEOU and PU can be established at a neural level.

The website the participants visited was of average PEOU and PU (based on a pretest evaluation of expert coders who performed the experimental task on the given website). Altogether, participants had to go through the process of choosing and buying a song online six times (see Figure 2). Each visit lasted a maximum of 6 minutes in order to have a relatively constant exposition to the website. After each visit, participants completed a questionnaire assessing the website PEOU and PU using Loiacono, Watson, and Goodhue's (2007) Webqual measurement scale. Forty-five participants (3 groups of 15) underwent the experimental protocol. The first group received right anodal and left cathodal stimulation, the second group received right cathodal and left anodal stimulation and the third group received placebo stimulation. The three groups consisted of 9, 5, and 10 females, and the average age was 22.41, 23.46, and 23.8 (SD: 2.64, 2.84, and 3.01).

Preliminary Results. Scores of the WebQual (Loiacono et al., 2007) were obtained after each visit and the scores were calculated separately for PEOU and PU. The results were standardized using Z scores and are reported in Table 1 and Table 2.

Table 1. PEOU scores for each visit, by group (average (std. deviation))

Visit	Anodal stimulation	Cathodal stimulation	Placebo stimulation
1	-.261 (1.25)	.370 (.937)	-.167 (1.16)
2	.028 (.903)	.328 (1.10)	-.177 (.919)
3	-.205 (1.09)	.313 (1.11)	-.255 (.865)
4	-.211 (1.04)	.416 (1.16)	-.373 (.819)
5	-.194 (.941)	.354 (1.16)	-.182 (.844)
6	-.200 (.902)	.370 (1.02)	-.084 (764)

Table 2. PU scores for each visit, by group (average (std. deviation))

Visit	Anodal stimulation	Cathodal stimulation	Placebo stimulation
1	-.270 (1.34)	.113 (1.05)	-.357 (1.06)
2	.308 (1.01)	.209 (1.05)	-.044 (.960)
3	-.127 (1.10)	.203 (1.05)	-.188 (.855)
4	-.114 (.976)	.161 (1.17)	-.267 (.929)
5	-.159 (1.02)	.258 (.951)	-.146 (.719)
6	-.003 (1.08)	.119 (1.15)	.053 (.750)

In order to determine if the modulation of the DLPFC's excitability changed the explicit reports of PEOU and PU, a repeated measures ANOVA comparing the three groups for each of the six visits was conducted. For PEOU and PU respectively, neither any between subjects main effect of group ($F(2) = 1.687$; $p = .199$), ($F(2) = .523$; $p = .597$), nor a within subject main effect of visit ($F(5) = .360$; $p = .875$), ($F(5) = 1.764$; $p = .122$) could be observed. The analysis also failed to find a significant interaction between these two variables ($F(10) = .456$; $p = .916$), ($F(10) = .185$; $p = .787$). As it was expected following Dimoka's results, modulating the DLPFC's excitability had no impact on subjective measures of PU. Altogether, our preliminary results point towards an absence of a specific effect of the DLPFC on technology acceptance decisions, at least with respect to the explicit report of PEOU.

In order to assess the implicit impact of the DLPFC on lower order cognitive processes potentially also involved in technology acceptance decisions, further neurophysiological and behavioral data is necessary. Methods similar to those used by Sénécal et al. (2012) could be applied.

References

- Dimoka, A., Pavlou, P. A., & Davis, F. D. (2011). Research Commentary-NeuroIS: The Potential of Cognitive Neuroscience for Information Systems Research. *Information Systems Research*, 22(4), 687-702.
- Fritsch, B., Reis, J., Martinowich, K., Schambra, H. M., Ji, Y., Cohen, L. G., & Lu, B. (2010). Direct current stimulation promotes BDNF-dependent synaptic plasticity: potential implications for motor learning. *Neuron*, *66*(2), 198-204.
- Hoshi, E. (2006). Functional specialization within the dorsolateral prefrontal cortex: a review of anatomical and physiological studies of non-human primates.*Neuroscience research*, *54*(2), 73-84.
- Loiacono, E. T., Watson, R. T., & Goodhue, D. L. (2007). WebQual: an instrument for consumer evaluation of web sites. International Journal of Electronic Commerce, 11(3), 51-87.
- Nitsche, M. A., Boggio, P. S., Fregni, F., & Pascual-Leone, A. (2009). Treatment of depression with transcranial direct current stimulation (tDCS): a review. *Experimental neurology*, *219*(1), 14-19.
- Ortiz De Guinea, A., Titah, R., & Léger, P. M. (2013). Measure for Measure: A two study multi-trait multi-method investigation of construct validity in IS research. *Computers in Human Behavior*, *29*(3), 833-844.
- Ridderinkhof, K. R., van den Wildenberg, W. P., Segalowitz, S. J., & Carter, C. S. (2004). Neurocognitive mechanisms of cognitive control: the role of prefrontal cortex in action selection, response inhibition, performance monitoring, and reward-based learning. *Brain and cognition*, *56*(2), 129-140.
- Riedl, R., Banker, R., Benbasat, I., Davis, F.D., Dennis, A., Dimoka, A., Gefen, D., Gupta, A., Ischebek, A., Kenning, P., Pavlou, P.A., Muller- Putz, G., Straub, D., van Brocke, J., and Weber, B. 2010. "On the Foundations of NeuroIS: Reflections on the Gmunden Retreat 2009," *Communications of the AIS* (27:15), 243-264.
- Sénécal, S.; Léger, P-M.; Fredette, M.; Riedl, R. (2012), "Consumers' Online Cognitive Scripts: A Neurophysiological Approach," in *Proceedings of the International Conference on Information Systems*, Orlando, Florida.
- Sparing, R., & Mottaghy, F. M. (2008). Noninvasive brain stimulation with transcranial magnetic or direct current stimulation (TMS/tDCS)—from insights into human memory to therapy of its dysfunction. *Methods*, *44*(4), 329-337.

Are IT habits Functionally Different from IT Intentions?

Anssi Öörni, University of Oulu, Jarmo Kuisma, Aalto University

Corresponding author: Anssi.Oorni@oulu.fi

It is important to correctly identify the behavioral mechanisms that hold people from adopting novel information technologies (IT) to be able to design interventions to overcome their influence (Polites and Karahanna 2012). To this end IT habit has been greeted "as a key alternative mechanism" behind individual use of information technology (Venkatesh et al. 2012). The current consensus is that "habit has relatively little conceptual overlap with intention," (Limayem et al. 2007, p. 709) which justifies the use of IT habit side by side with IT intention in models predicting IT use. While intentional IT use is conscious and controlled IT habits are non-conscious and automatic. Such mechanistic habits do not consume cognitive resources, and can perform in parallel with cognitive tasks.

The alternative view is that IT habit is goal-oriented rather than mechanistic (Ortiz de Guinea and Markus 2009). This view is aligned with the current position of cognitive psychology on automatic behaviors (for a recent review, see Custers and Aarts 2010): Regularly pursued behaviors can be initiated from outside conscious awareness yet they remain goal-directed (Aarts and Dijksterhuis 2000) and are usually in line with one's values and general goals (Ajzen 2002). This suggests that intentional and habitual IT use may be functionally similar – apart from habits being non-conscious. The test for their similarity is whether IT habit employs the same resources as intentional IT use. That is, whether IT habit is supported by *executive functions*, collectively known as the *executive control*, which maintain the mental representations of goals during their execution (Marien et al. 2012)

The emerging view in cognitive psychology holds that executive control is required even for automatic behaviors. A growing body of empirical research supports this position. First, it has been shown that non-consciously activated goals can remain active for extended periods of time (Aarts et al. 2008; Aarts et al. 2009; Bargh et al. 2001). Second, non-conscious goals can inhibit competing goals to protect themselves from distraction (Aarts et al. 2007; Papies et al. 2008; Shah et al. 2002). Third, when goal attainment is important, non-conscious goals are capable of promoting behavior in novel settings and in the face of obstacles (Aarts et al. 2004; Custers and Aarts 2005a; Custers et al. 2008; Eitam et al. 2008; Hassin et al. 2009). Pursuit of non-consciously activated goals also appears to involve feedback (Custers and Aarts 2005b; Moskowitz et al. 1999): Behavioral situation that is discrepant with the goal encourages people to adapt their behavior. More recently, direct evidence showing that operation of non-conscious goals depends on cognitive resources and is effortful has emerged (Marien et al. 2012).

In this paper, we seek to answer the following research question: Are *IT habits* goal-oriented or "hard-wired" as suggested by the dominant IT use theory. We employ the classic dual-task laboratory experiment (Pashler 1994) with eye tracking equipment and test whether automatic avoidance of banner ads, also known as *banner blindness* (Burke et al. 2005), degrades the performance of a simultaneous reading task. Banner blindness is functionally related to those observations (Schneider and Shiffrin 1977; Shiffrin and Schneider 1977) that were central to formulation of the dominant IT habit theory, which justifies banner blindness be called a *habit* in the sense IS literature has given to the concept.

We operationalize our research question through a number of testable hypotheses. The first group of these hypotheses is related to testing presence of banner blindness: 1) Banner ads are entered less frequently than ads appearing in other screen locations. 2) Banner ads are fixated less frequently than ads appearing in other screen locations. To see if habitual avoidance of banner ads impairs a simultaneous cognitive task, we test whether presence of banner ads has a negative influence on reading. High reading performance is related to high reading rate (words per minute), short fixations on text, and low frequency of regressions (right-to-left eye movements). We formulate the hypotheses that test the influence of banner blindness on reading task as follows: 3) Presence of a banner ad decreases the reading rate. 4) 4) Presence of a banner ad increases the duration of fixations on text. 5) Presence of a banner ad increases the number of regressions during reading.

Participants and apparatus. Thirty volunteers with normal or corrected-to-normal vision gave an informed consent and were paid to participate in the experiment. Eye movements were recorded by a Tobii 1750 remote eye-tracking system with a spatial accuracy of .5°. The screen coordinates of both eyes were sampled at 50 Hz. For each participant, the system was calibrated before the experiment using a set of sixteen calibration points shown one at a time and covering the whole screen area. The stimuli were presented on a 17-inch display with a screen resolution of 1024 x 768 pixels. The display was located on a table at the distance of approximately 60 cm from the participants' eyes.

Materials. The stimuli comprised 32 web pages each containing a text and two ad areas, one above (banner) and one to the right (skyscraper) of the text. The text material came from 32 online magazine articles with mean length of 104 words and range of 90 – 118 words. The length average of words was 6.8 characters. The texts were displayed in a 14-point Arial font, the character height average was .4°, and width average .3° from the viewing distance. The advertisements comprised 64 full-color ads of 16 different topics. Four professionally designed ad versions (banner vs. skyscraper; animated vs. static) of each topic were used to control for the effects of ad content. Each participant saw all 64 ads; the same topic never appeared both as a banner and a skyscraper on a web page. Animations included different combinations of horizontal, vertical and rotating movement, and text or graphics fading in or out. The banners subtended 14.4° x 2.0° (468 x 60 pixels), and the skyscrapers subtended 4.4° x 11.6° (140 x 350 pixels). We used a Latin-square design in which each participant read eight texts per condition (combination of static and/or animated ads), and every text was read by equal number of participants. Texts and ad combinations were randomly assigned to different conditions to prevent possible interactions between the text and ad contents. The conditions were presented in randomized order with a Java servlet based stimulus onset system, and displayed using Internet Explorer web browser. The web pages fitted in one screen.

Procedure. We informed the participants that the experiment was about online reading, and instructed them to read the 32 texts for content. The participants read the texts at their own pace, and we measured their eye movements during this time. When finished reading a text, the participants clicked on a push button, which opened a new web page with a four-choice question. Answering the question displayed the next stimulus. After seeing all 32 stimuli and answering the related content questions, we asked the participants to rate on a five step Likert scale whether they had paid attention to ads and if the ads had interfered with reading.

Data analyses. We extracted fixations, saccades and blinks from the raw eye coordinate data with the Tobii Clearview software using a window-based algorithm with 40 pixel window and 100ms minimum fixation duration.

To measure reading performance as a function of the overall scanning behavior on the page, we calculated reading rate as the number of words divided by the time spent on the page (words per minute, wpm). To test whether attention to ads (fixations to the ads) or inhibiting attention to ads (decreased reading rate in the absence of attention to ads) interfered with reading, we calculated eye movement measures separately for the ad and the text regions. We calculated number of entries and total number of eye fixations to measure attention to ads. To measure reading difficulty, we calculated number of entries on the text region, mean fixation duration, and number of saccades that were directed backward on the current line (regressions), for the text region (reviewed in Rayner 1998).

Reading performance and eye movement measures for the text area were studied with repeated measures analysis of variance (ANOVA). Generalized Estimating Equations (GEE) model was used for the eye movement measures for the ads.

Results. On average participants fixated banners on 14% of trials while they fixated skyscrapers on 20% of trials. Number of entries [$\chi^2(1)=18.24$, $p<.001$] and fixations [$\chi^2(1)=27.45$, $p<.001$] were higher for skyscrapers than for banners (**H1 and H2 supported**). Ad position affected reading rate [$F(1, 26)=6.48$, $p=.017$, $\eta p^2 =.199$]: Reading was slower when banner was present compared to when skyscraper was present. Presence of banner was also related to longer mean fixation duration during reading [$F(1, 26)=11.73$, $p=.002$, $\eta p^2 =.311$] and greater number of regressions [$F(1, 26)=6.29$, $p=.019$, $\eta p^2 =.195$] on the text region (**H3, H4, and H5 supported**).

We find that online ads that appear in somewhat unexpected locations draw more overt attention than those ads that appear in the most expected location on top of the Web page. That ads appearing in the most expected locations, in turn, interfere more with the simultaneous cognitive task tells us that these ads are inhibited with some effort. This finding supports the idea that people learn strategies of avoiding online ads in their visual field. Banner blindness is related to impaired reading, which tells us that the habit consumes cognitive resources and occupies the *executive control*. We conclude that banner blindness, which can be considered in many ways the epitome of IT habit, is goal-oriented behavior. Thus, IT habits seem to be functionally identical with intentional behaviors save for the absence of conscious intention. Our findings suggest that we should reconsider the theoretical justification of using IT habit as a complement to IT use intention in IT use models.

Our findings suggest that the current IT habit theory is in need of mending. The only major difference between habitual and intentional IT use seems to be that habits are carried out with limited awareness, a relatively unimportant difference by the standards of modern cognitive psychology (Custers and Aarts 2010; Dijksterhuis and Aarts 2010): Intentions are merely conscious representations of goal pursuit (Bargh and Morsella 2009). The academic importance of our findings lies in the advice they give for improving predictions of IT use: It is not meaningful to say that IT habits limit the predictive power of IT intentions, for habitual and intentional IT use are both goal-oriented behaviors. We have a number of competing explanations for the low IT intention-IT use relationship (e.g. Burton-

Jones and Straub 2006; Bagozzi 2007). Providing evidence against the currently favored explanation should motivate IS researchers to invest their future efforts in testing these more fruitful avenues for closing the gap between IT intentions and IT use.

References

- Aarts, H., and Dijksterhuis, A. 2000. "Habits as knowledge structures: Automaticity in goal-directed behavior," *Journal of Personality and Social Psychology* (78), pp. 53-63.
- Aarts, H., Custers, R., and Holland, R.W. 2007. "The nonconscious cessation of goal pursuit: When goals and negative affect are coactivated," *Journal of Personalíty and Social Psychology* (92:2), pp. 165-178.
- Aarts, H., Custers, R., and Marien, H. 2009. "Priming and autorship ascription: When nonconscious goals turn into conscious experiences of self-agency," *Journal of Personality and Social Psychology* (69:5), pp. 967-979.
- Aarts, H., Custers, R., and Veltkamp, M. 2008. "Goal priming and the affective-motivational route to nonconscious goal pursuit," *Social Cognition* (26:5), pp. 555-557.
- Aarts, H., Gollwitzer, P.M., and Hassin, R.R. 2004. "Goal contagion: Perceiving is for pursuing," *Journal of Personalíty and Social Psychology* (87:1), pp. 23-37.
- Ajzen, I. 2002. "Residual effects of past on later behavior: Habituation and reasoned action perspectives," *Personality and Social Psychology Review* (6:2), pp. 107-122.
- Bagozzi, R.P. 2007. "The legacy of the technology acceptance model and a proposal for a paradigm shift," *Journal of the Association for Information Systems* (8:4), pp. 244-254.
- Bargh, J.A. 1990. "Auto-motives: Preconscious determinants of social interaction," in *Handbook of motivation and cognition: Foundations of social behavior*, E.T. Higgins, and R.M. Sorrentino (eds.), New York, NY: The Guilford Press, pp. 54-93.
- Bargh, J.A., Gollwitzer, P.M., Lee-Chai, A., Barndollar, K., and Trötschel, R. 2001. "The automated will: Nonconscious activation and pursuit of behavioral goals," *Journal of Personality and Social Psychology* (81:6), pp. 1014-1027.
- Bargh, J.A., and Morsella, E. 2009. "Unconscious behavioral guidance systems," in *Then A miracle occurs: Focusing on behavior in social psychological theory and research*, C.R. Agnew, D.E. Carlston, W.G. Graziano, and J.R. Kelly (eds.), Oxford University Press, pp. 89-118.
- Burke, M., Hornof, A., Nilsen, E., and Gorman, N. 2005. "High-cost banner blindness: Ads increase perceived workload, hinder visual search, and are forgotten," *Transactions on Computer-Human Interaction* (12:4), pp. 423-445.
- Burton-Jones, A., and Straub, D. 2006. "Reconceptualizing system usage: An approach and empirical test," *Information Systems Research* (17:3), pp. 228-246.
- Custers, R., and Aarts, H. 2005a. "Positive affect as implicit motivator: On the nonconscious operation of behavioral goals," *Journal of Personality and Social Psychology* (89:2), pp. 129-142.
- Custers, R., and Aarts, H. 2005b. "Beyond priming effects. The role of positive affect and discrepancies in implicit processes of motivation and goal pursuit," *European Review of Social Psychology* (16), pp. 257-300.
- Custers, R., and Aarts, H. 2010. "The unconscious will: How the pursuit of goals operates outside of conscious awareness," *Science* (329:47), pp. 47-50.
- Custers, R., Maas, M., Wildenbeest, M., and Aarts, H. 2008. "Nonconscious goal pursuit and the surmounting of physical and social obstacles," *European Journal of Social Psychology* (38), pp. 1013-1022.
- Dijksterhuis, A., and Aarts, H. 2010. "Goals, attention, and (un)consciousness," *Annual Review of Psychology* (61), pp. 467-490.
- Eitam, B., Hassin, R.R., and Schul, Y. 2008. "Nonconscious goal pursuit in 0novel environments: The case of implicit learning," *Psychological Science* (19:3), pp. 261-267.
- Fishbach, A., Friedman, R.S., and Kruglanski, A.W. 2003. "Leading us not unto temptation: Momentary allurements elicit overriding goal activation," *Journal of Personality and Social Psychology* (84), pp. 296–309.
- Hassin, R.R., Bargh, J.A., and Zimerman, S. 2009. "Automatic and flexible: The case of non-conscious goal pursuit," *Social Cognition* (27:1), pp. 20-36.
- Kim, S.S., Malhotra, N.K., and Narasimhan, S. 2005. "Two competing perspectives on automatic use: A theoretical and empirical comparison," *Information Systems Research* (16:4), pp. 418-432.
- Limayem, M., Hirth, S.G., and Cheung, C.M.K. 2007. "How Habit Limits the Predictive Power of Intention: The Case of Information Systems Continuance," *MIS Quarterly* (31:4), pp. 705-737.
- Marien, H., Custers, R., Hassin, R.R., and Aarts, H. 2012. "Unconscious goal activation and the hijacking of the executive function," *Journal of Personality and Social Psychology* (103:3), pp. 399-415.
- Moskowitz, G.B., Gollwitzer, P.M., Wasel, W., and Schaal, B. 1999. "Preconscious control of stereotype activation through chronic egalitarian goals," *Journal of Personality and Social Psychology* (77:1), pp. 167-184.
- Ortiz de Guinea, A., & Markus, M.L. 2009. "Why break the habit of a lifetime? Rethinking the roles of intention, habit, and emotion in continuing information technology use." *MIS Quarterly* (33:3), pp. 433-444.
- Papies, E.K., Stroebe, W., and Aarts, H. 2008. "Healthy cognition: Processes of self-regulatory success in restrained eating," *Personality and Social Psychology Bulletin* (34), pp. 1290-1300.
- Pashler, H. 1994. "Dual-task interference in simple tasks: Data and theory," *Psychological Bulletin* (116:2), pp. 220–244.
- Polites, G.L., and Karahanna, E. 2012. "Shackled to the status quo: The inhibiting effects of incumbent system habit, switching costs, and inertia on new system acceptance," *MIS Quarterly*, (36:1), pp. 21-42.
- Rayner, K. 1998. "Eye movements in reading and information processing: 20 years of research," *Psychological Bulletin* (124:3), pp. 372-422.
- Schneider, W., and Shiffrin, R.M. 1977. "Controlled and automatic human information processing: I. detection, search, and attention," *Psychological Review* (84:1), pp. 1-66.
- Shah, J.Y., Friedman, R., and Kruglanski, A.W. 2002. "Forgetting all else: On the antecedents and consequences of goal shielding," *Journal of Personality & Social Psychology* (83), pp. 1261–80.
- Sheeran, P., Aarts, H., Rivis, A., Webb, T.L., and Cooke, R. 2005. "The goal-dependent automaticity of drinking habits," *British Journal of Social Psychology* (44:1), pp. 47-63.
- Shiffrin, R.M., and Schneider, W. 1977. "Controlled and automatic human information processing: II. perceptual learning, automatic attending, and a general theory," *Psychological Review* (84:2), pp. 127-190.
- Venkatesh, V., Thong, J. Y. L., and Xu, X. 2012. "Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology," *MIS Quarterly* (36:1), pp. 157-178.

Reinforcing Upward Spiral Inspiration for Technology Acceptance: A NeuroIS Fuzzy Statistical Structured Equation Approach to Improve Software Training Results by Harnessing Natural Neuro-Physiological Steroid Performance Enhancement Hormones

James A. Rodger, Indiana University of Pennsylvania, USA

jrodger@iup.edu

This paper addresses the problem of predicting inspiration utilizing an upward spiraling inspiration model for technology acceptance. Monitoring of cortisol levels provided feedback for a decision support system that measured errors and elapsed time for training tasks completed by end-users of a health care application. The training success was measured utilizing statistics, SEM and a Fuzzy approach. The predictive model was implemented by comparing the regression, fuzzy logic and SEM results. Data collected from 338 health care workers were used to test a proposed model that inspiration, memory, and inspirational memory affect end user intention to adopt a digitized patient record software application. Structural equation modeling showed that, as expected, inspiration affected the individual behavior of the end users. Inspiration had an interactive impact through memory on collective acceptance of the technology, thereby affecting subsequent evaluations and behavior. The proposed model was nomologically validated through the use of a portable platform loaded with software for the electronic collection of operational-level health care data. Embedded metrics measured participants' memory as operationalized by task completion time, number of errors, and completeness of the data. In order to triangulate the results, salivary cortisol levels collected from 74health care workers were used to measure whether inspiration improves memory and affects end user intention to adopt the application through reduced errors and decreased completion times. NeuroIS is a relatively new approach for studying training (Leger et al: forthcoming). To this point, most research revolving around end user beliefs have been purely behavioral (Ortiz de Guinea, Titah and Léger: forthcoming). However recent studies have begun to utilize biosignal, and neuro-physiological approaches to study these effects (Randolph, Borders and Loe: 2013). Even factors such as the impact of emotion upon training success are being reexamined from a NeuroIS perspective (Leger, Reidl & vom Broche: forthcoming). It is with this pioneering spirit that a group of end-users are examined from multiple perspectives ranging from behavioral to physiological, in this paper. Statistical, SEM and Fuzzy approaches are examined and used to triangulate the data. Charnes, Cooper, and Rhodes (1978) introduced the idea of comparing efficiencies of different decision-making units. We use three techniques in this study. The first utilizes the fuzzy technique to determine cortisol and inspiration levels as measured by time and errors. Bhaskar, Pal, and Pal (2011) used a heuristic method for a resource-constrained project scheduling problem with fuzzy activity times that we adapt to determine whether an increase in cortisol levels leads to decreases in errors and decreases in time to complete training tasks with a corresponding increase in inspiration in a reinforcing and an upward spiraling manner. The second is statistical approach utilizing regression and descriptive insights. The third is the SEM, which has been used in the past to predict behavioral perspectives. The present paper contributes to the literature by proposing a model that takes into account the roles of inspiration, physical measures of memory (i.e., time to complete a script and number of errors), and the measurement of salivary levels of Cortisol. This pilot study is exploratory and investigates the feasibility of a framework to show that the stimulus in question could actually manipulate inspiration and memory. Therefore, we conducted a study to test end user salivary Cortisol levels as a surrogate for end user acceptance of a medical software package that facilitated the digitization of electronic health records. Users evaluated their intention to use the technology based on the TAM model. TAM is often used to obtain user evaluations of information technologies. The assumption is that "users will give evaluations based on the extent to which systems meet their needs and abilities" (Davis 1989). For the purpose of our study, we define user evaluations as user perceptions of the ease of use and perceived usefulness of the medical modules based on their ability to complete tasks in a timely and reduced error environment. Our model is as follows and the hypotheses follow from the model: Inspiration → increased salivary cortisol → increased memory → decreased errors and time → better perceptions. Participants were 74 end users from around the nation. Participants' mean age was 39.61 years (SD = 1.24). They included medical doctors (46.8 percent), nurses (25.7 percent), ancillary service personnel (17.8 percent), and health care staff (9.7 percent). Participants were not biased toward either gender and were asked not to drink any fluids during the training. The participants voluntarily agreed to the training at a major international medical conference. Thirty-seven of the participants were randomly selected for the control group and 37 in the treatment group and placed in separate rooms. All 74 participants were given a baseline salivary Cortisol swab at 9:00 am as a pretest. Then the treatment group viewed the "I'm an IBMer. Let's build a smarter planet" video clip and listened to an inspirational speech on how the handheld technology could be used to improve patient care through decreased time and errors. Trainers gave sufficient training to enable participants to operate and evaluate the modules.

The training program included instruction, handouts, and hands-on training with the modules on handheld devices. A customized training application was installed on each device, and the instructors guided the users in working with it to learn how to operate the equipment and modules. Both groups were tested for salivary cortisol as a baseline and upon completion of the tasks and TAM survey. The instructors ensured that all users were thoroughly familiar with the equipment, modules, and objectives of the study before they participated in the evaluation. The instructors taught the users how to operate the device and module controls, enabling them to follow the steps of operation from startup to shut down. The users also learned the steps that they would be asked to follow during the evaluation, including entering data into the modules according to scenarios developed by us. When training concluded, the users were able to switch on the devices, open the modules, enter data according to scenario test scripts, print the form associated with the scenario, close the modules, and switch off the devices. Throughout the process, personnel familiar with the modules and scripts were on hand to provide support and answer questions. After successful completion of training, participants completed four scripts using the medical software modules. The scripts guided the users through the process of completing medical forms. Code embedded in the software captured date/time metrics regarding the length of time it took users to enter data associated with each form. After users completed a script, they printed the applicable forms using wireless printers supplied by us. Upon conclusion of the field testing a posttest salivary Cortisol sample was taken from both groups. The personnel collected the devices installed with the medical modules. We reviewed and analyzed the date/time metrics collected by the embedded code. We calculated and report here descriptive statistics for each script as well as data on the completeness and accuracy of the forms. Descriptive statistics were initially run in order to establish the distribution of the data and whether parametric or nonparametric methods are suitable for analysis. Given the limitations in the application of linear regression, it is likely that fuzzy logic approaches can be applied to the upward spiraling inspirational model to predict the error and time metrics. For example, fuzzy logic rules can be established for such continuous variables as cortisol level, time elapsed and errors made.

The current study makes several contributions to the literature. First, it is the first generalizable, national survey to attempt to experimentally manipulate inspiration and its effect on intention to use technology and on memory through measurements of salivary cortisol. Second, it reveals that when end users in the treatment group reported changes in inspiration, they also had improved memory and concentration to complete test scripts in a more timely and accurate manner than end users in the control group. Third, to our knowledge this is the first study of the impact of inspiration on memory (as measured by time to complete a script and number of errors in the script) in a sample of technology end users and the first study to measure their interaction. Also, this was the first attempt to measure intention to use technology with a method other than perceptual surveys. The model presented here is unique because it incorporates inspiration into the TAM model to measure its effect on intention to use technology. We adapted the TAM model to develop an instrument for obtaining user evaluations of medical modules used after hearing an inspiring video clip and invigorating speech. The results showed that treatment group had increased cortisol levels, improved memory, and greater intention to use with fewer errors made and a shorter task completion time relative to the control group. We postulate that inspiration was the major factor that affected overall intention to use the software modules and was responsible for participants' increased perceptions that the applications were easy to use and useful, that the applications satisfied their needs, and that they felt inspired to use the applications. The results of the survey showed that study participants were satisfied that the modules performed most data collection functions very well. Participants also indicated that the modules could be useful tools for collecting and disseminating data and would allow users to obtain, evaluate, and present information more efficiently than with previous methods. Overall, participants indicated that the medical modules had significant potential utility for digital data collection. Furthermore, the results showed that the video clip successfully inspired and motivated the end users. As expected, participants reported significant increases in inspiration and intention to use the technology after viewing the inspiring clip. What makes a stimulus inspiring is its "perceived intrinsic value" rather than its reward value. If a person perceives a stimulus as inspiring, this will increase his or her motivation to know, accomplish, or experience. In this study, participants were open to the stimulus (i.e., the inspirational speech and video clip), which increased their motivation to accept the technology in question. Based on these results, we conclude that participants found value in the stimulating video clip as reflected by the fit of inspiration into the TAM. Finally, not only did the inspirational speech increase end user inspiration, but this then facilitated increases in memory as measured by decreases in time to complete the script and number of errors in the script and increased salivary cortisol levels. This study suggests several potential avenues for future research. First, future research needs to examine populations other than medical technology end users to determine the consequences of inspiration among these populations. Moreover, individual differences due to gender or personality traits may have different effects on inspiration and motivation. Because different personality traits are correlated with inspiration, understanding individual differences can help researchers better understand inspiration. Second, researchers should examine the consequences of change in inspiration in end users to clarify the role of inspiration versus motivation in technology acceptance. Future research should also test whether the antecedents of inspiration lead to increased inspiration. Third, simple memory experiments could be performed to determine whether inspiration leads to performance gains. Fourth, the role of administrators in this area should be studied. Fifth, researchers need to determine whether inspiration leads to absorption, creativity, and optimism, constructs with which it is correlated. If inspiration can indeed increase an end user's focus (i.e., absorption) or influence the end user to be creative, then it may facilitate better performance. Social-contextual influences may also increase inspiration and affect motivation, as it is well documented that such influences help facilitate autonomy, relatedness, and competence. Sixth, the field would benefit from more robust, larger measures of salivary cortisol that include attitude, social norms, perceived behavior control, facilitating conditions, motivation, memory, inspiration, and their interactions. Studying interactions between time and errors and all of the inspiration variables may provide more insights into inspired memory. Finally, positron emission tomography and other neuroscience imaging tools could be used to study the effects of inspiration and memory on intention. Inspirational memory forms a bridge between social and cognitive psychology and paves the way to neuro-information systems. It affects intention to use both emotionally (through idea inception from the inspiration) and physically (by improving memory through reduced time to complete a training script and reduced number of errors on the script). The next step in the progression of this research should be to measure brainwaves using positron emission tomography and other imaging tools. We used fuzzy logic to develop a cortisol membership function that could be used to find the subsequent optimal inspiration level to decrease errors and elapsed time, for a task software application training exercise. We demonstrated that the cortisol levels provide a good estimate through the fuzzy system to identify inspiration feedback as an effective method of reducing errors and time. We tested our fuzzy logic system and compared the results to actual outputs from the cortisol and SEM experiments. We found that a cortisol level of 5 μg/dL corresponded with many errors and slow time to completion. Similarly, a cortisol level of 40 μg/dL demonstrated no errors and a fast time to complete the assigned task. The present research began in 2008 with the aim of exploring the use of a portable platform for the electronic collection of operational-level medical information at the point of care. We found that the use of an inspirational stimulus increased end user memory through fewer errors on the devices and less time to complete a task while enhancing intention to use the technology and increasing salivary cortisol levels. Thus, the modules used in this study show promise for improving patient care through increased accuracy of data and decreased errors resulting from transcription. The use of these modules on a handheld device would also increase flexibility in data collection during fieldwork. Our software team is currently using participant feedback and end user data to make improvements to the modules. The present results suggest that inspiration may be a particularly salient construct in the domain of technology acceptance. However, more research is necessary. Managers need to know how to increase autonomy among end users, because this will result in end users having a better experience and being more likely to adhere to tough and demanding training programs. Inspiration is a new and little known variable that warrants future research because of its link to performance gains and positive emotions both inside and out of the technology acceptance context. In addition, other salivary components, such as epinephrine, should be explored as a consequence of inspiration on memory and intention to use technology. The management information systems community needs to move away from predominantly survey-based methodologies to more scientific methods of measuring end users' true intent to adopt technology if progress is to be made in this area of research. The triangulation of the SEM model, the regression model, and the salivary cortisol model supports the TAM model. The end users perceptually rated the software application favorably in terms of its perceived ease of use, perceived usefulness, and use. The SEM model provides evidence that inspiration is a latent factor that effects use and memory. The salivary cortisol measurements lend credence to the contention that inspiration increased end user memory by decreasing errors and time to completion in training scripts. In summary, men and women from a medical conference session on a healthcare software application demonstration gave saliva samples before and after training. For both men and women, an inspirational video substantially increased saliva cortisol compared to the control group. Participants were asked to fill to a 5 ml line marked on the side. This procedure was repeated immediately after the end of the training so that samples were received within 15 min after training completion. Samples were stored at approximately -20 degrees C within 30 min after collection and the frozen samples were later sent to the lab for processing. Test volumes were 25 μl. Statistics showed that inspiration from software trainers affected individual behavior. Inspiration had an impact, through memory, on acceptance of the technology. The cortisol levels of 37 "inspired" end users were measured and compared to those of a control group (n = 37). The inspired group demonstrated a 15% increase in baseline salivary cortisol levels. Inspiration is a key driver that improves memory to affect end user intention to use.

A NeuroIS Platform for Lab Experiments

Marius B. Müller, Anuja Hariharan, Marc T. P. Adam
Karlsruhe Institute of Technology (KIT)

Corresponding author: marius.mueller@kit.edu

Problem Identification and Motivation

NeuroIS research necessitates the collection of high quality empirical data (Dimoka et al. 2012). In particular, research in this domain necessitates the collection of psychophysiological and neuroimaging data synchronized to a subject's current context. Here, context refers to the environment and the behavior of the observed subject, e.g., decisions during an auction, answers on a questionnaire, or the time to complete a control task. Due to the controlled environment, many researchers use lab experiments to conduct their studies and collect the above described data (Falk & Heckman 2009).

Software used in these lab experiments, either third-party or customized software, often suffers from a number of limitations, such as (i) a limited set of functionalities, both for the user interface and the experimental structure, (ii) data collection and storage being spread over several different tools, which results in data synchronization problems and time consuming post-experiment data cleaning, (iii) being limited in subject size or possibilities in subject interaction, (iv) requiring to learn new or proprietary programming languages in addition to heavy programming effort, (v) no extensibility to handling emerging and changing software and hardware, e.g., new operating systems or new bio sensor technology, (vi) missing flexibility to handle requirements of experimental economists, IS researchers, or to meet future requirements, such as integrating physiological data to research technostress (Riedl et al. 2012).

Objectives of the Solution

Following a design science approach (Peffers et al. 2008), we next define broad objectives of a possible solution to address the problems stated above.

- Facilitating the creation of lab experiments by reducing development time and cycles
- Facilitating individual & group interactions in a controlled lab setting
- Integrating measurements of bio sensors and logging of physiological data specific to subject events
- Ease of event logging and data storage, enabling experiments to scale in time and subject size
- Meeting emerging technical requirements in the field of IS research and experimental economics

Design and Development

To address these objectives, we herewith present a Java™-based platform, which provides functionalities necessary to run NeuroIS lab experiments while, at the same time, offering flexibility to adapt to experiment specific requirements. The platform implementation is inspired by Smith's (1982) definition of an experimental system. In combination with the integration of bio sensors, the platform can be used in many research disciplines, which seek to apply a NeuroIS approach, e.g., design science (vom Brocke et al. 2013), biofeedback (Jercic et al. 2012), consumer research (Koller et al. 2012), and educational software (Chintalapati et al. 2010). The platform's support for experiments with multiple and simultaneously interacting subjects, for group or market experiments, offers numerous possibilities for NeuroIS research.

The platform's software architecture is divided into two parts (see Figure 1): a built-in part (*core components*) and a customizable part (*experimental design* and *bio sensors*). The *core components*, which are provided by the platform, form the robust foundation. They handle, for instance, client-server communication, database logging with client and server timestamps on millisecond precision, and the management of experimental sessions, i.e., all the required building blocks essential to almost all lab experiments. Also provided by the *core components* is an internal database, which makes the use of a dedicated database server optional.

On top of the *core components*, the customizable parts are implemented by the researcher. Both customizable parts, the *experimental design* and *bio sensors*, are based on the idea of modules, i.e., they are developed independently and added to the *core component* as needed. First, the *experimental design* which defines the actual experiment. Here, the researcher implements all elements and "rules" of the experiment, e.g., the experimental procedure, the matching of subjects and groups, and the options for subjects to interact. The *experimental design* also defines the visualization of the experiment, i.e., the user interfaces, which are shown to the subjects. Since there are no restrictions to what Java™ elements can be integrated into the design of the user interfaces, all elements can be included from simple elements, such as images and videos, to more complex elements, such as dynamic real-time charts and the integration of websites through a built-in web browser element.

The second part, which is implemented by the researcher, is the *bio sensors*. This optional part is used to integrate support for various bio sensors into the platform. To facilitate the integration, the platform provides a general framework for handling bio sensors, which can be adapted by the researcher when integrating support for his or her specific bio sensor. This general bio sensors framework provides functionalities for a centralized control in order to manage and operate all connected bio sensors simultaneously—especially useful in experiments with multiple subjects. These provided functionalities include starting and stopping data recordings, defining storage strategies, and monitoring the bio sensors' connection and overall data quality. As a result, using bio sensors in lab experiments becomes less time consuming, since bio sensors do not have to be setup or monitored individually. In addition, the recorded data is available instantaneously within the platform and can therefore be included into the experimental design itself, e.g., by using physiological data to create a real-time biofeedback element in the user interface.

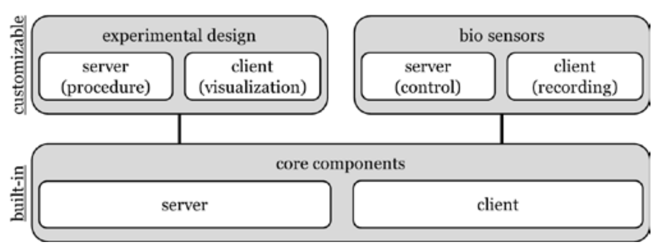


Figure 1. Basic platform architecture

Demonstration

Next, as part of the demonstration, and to observe how well the developed artefacts solve the above mentioned problems better, we present two use cases that were implemented using the proposed platform. Use case (1) implements a single-subject auction experiment, whereas use case (2) implements a multi-subject auction experiment. Both experiments were conducted with different sets of bio sensors.

Use case 1: Measuring interplay of emotions and workload in auctions.

This use case is an auction experiment on 54 subjects wherein subjects' brain activity was recorded using a 32-channel electroencephalograph (EEG) along with their electrocardiogram (ECG) and skin conductance (SC) data. The platform enabled the interaction between each subject and 2 computer opponents in different auction types and conditions, namely ascending and descending auctions. The aim of the experiment was to understand how the IS constructs (arousal and workload) are influenced by the auction types and conditions, and how they in turn impact subjects' bidding behavior. By means of the platform, events of interest (such as information events, placing of bids, outcome, and regret information) were logged directly to the database along with client and server timestamps. Synchronously, triggers were added from the Java™ interface of the platform to the EEG data through suitable Java™ wrappers to perform system-level calls, and transmit the event trigger via parallel port, along with the timestamp information. In parallel, heart rate and skin conductance data were transmitted over Bluetooth, and stored on the local client.

Use case 2: Investigating the influence of auction fever on bidding behavior in auctions.

The second use case was conducted with a total of 216 subjects where ECG, SC, and plethysmography data were recorded. During this experiment, nine subjects at a time competed in groups of three in multiple ascending auctions. For each auction, groups were automatically re-matched to achieve a perfect stranger matching. Before the experiment started, all subjects had to successfully complete a questionnaire on the experiment's instructions in order to ensure that they understood the upcoming events. Using the platform's built-in questionnaire capabilities, the experiment was set to wait for all subjects to complete the questionnaire and only then continue with the actual experiment. Next, subjects could choose an individual name and picture, which later was used in the experiment to show subjects their current competitors in the user interface. By choosing and implementing a between-subjects design, the experiment had a 2x2 full-factorial treatment structure. Using the platform's session manager, the sequence of treatments was set, such that all treatments were conducted equally often and that they were properly distributed over time to avoid, for example, time-of-day biases. The recorded events of interest were similar to those of use case (1), e.g., the placing of bids and the auction outcome, in addition to the simultaneously recorded bio sensor data. Due to the high amount of data produced by the bio sensors during an auction, the data was first stored on each local client and then was moved automatically to a central storage location after all auctions were completed.

Evaluation

The initial evaluation of the presented platform shows that the experiments in both use cases were programmed with ease, conducted successfully, and enabled easy data handling post-experiment—hence, indicating the potential of this NeuroIS platform.

Also, the platform meets the previously defined objectives. Creating an experiment is less time consuming, since the necessary basic building blocks are already provided, and the well-known and widely available programming language Java™ is used for implementations. Researchers therefore can focus their attention on the design and calibration of their experiments, rather than spending time and effort on re-developing generic and existing software solutions, e.g., client-server communication. This provided client-server communication in particular allows researchers to create experiments where subjects can not only act individually, but also interact in group or market experiments with no additional overhead in the implementation. In combination with the integrated bio sensor functionalities, the platform facilitates measuring and logging of physiological data as well as context data of the conducted experiment. All this results in less effort spent for the collections, cleaning, and preparation of data, which reduces data errors and provides more time for the statistical analyses of interest. At the same time, since the platform is an open-source software project, any researcher can adapt the platform to meet new emerging requirements in his or her respected domain of research.

Additional evaluation was provided by presenting the platform to members of various departments at the Karlsruhe Institute of Technology (KIT). Thereby, valuable feedback was provided and incorporated into the implementation of the platform. As a consequence, two upcoming studies now use the platform to implement their experiments, one study in the area of telecommunication markets and one in the area of risk management.

Communication

The platform will be distributed as a pre-compiled version for instant use, where the application can be started either as a client or as a server, as well as a version including a ready-to-use development workspace for easy access to own implementations. The source code will be available as a version controlled repository, which can be downloaded, modified, and used to include community feedback, such as bug-fixes and new features. As examples, three implemented sample experiments will be provided. In addition, tutorials will be made available in the form of sample sensor setups, documentation of the architecture explaining core concepts, and documentation of source code where necessary. Technical support will be provided through commonly used tools, such as issue trackers and forum discussions. Finally, the importance of the artifact, its usefulness and originality, as well as several aspects of the design and architecture will be communicated through scholarly research publications.

Contribution

The presented platform serves as a stable prototype to implement experiments involving physiological measurements and strategic interactions. Following an iterative design science process, the next steps are to examine the existing requirements critically and redefine new ones, where necessary. Based on these, the available features will have to be further developed, incorporating feedback from NeuroIS researchers, and cater to the needs of a broader community of researchers to use the platform for their studies.

Finally, the presented software platform facilitates the conduction of NeuroIS lab experiments, which hopefully inspires researcher to employ NeuroIS experiments.

References

- Chintalapati, Arun; Sheng, Hong; Hall, Richard; Landers, Robert (2010): Evaluation of Rapid Development System using Eye Tracker. In Proceedings of the 2010 American Society for Engineering Education Annual Conference (ASEE).
- Dimoka, Angelika; Banker, Rajiv D.; Benbasat, Izak; Davis, Fred D.; Dennis, Alan R.; Gefen, David et al. (2012): On the use of neurophysiological tools in IS research: Developing a research agenda for NeuroIS. In MIS Quarterly 36 (3), pp. 679–702.
- Falk, Armin; Heckman, James J. (2009): Lab experiments are a major source of knowledge in the social sciences. In Science 326 (5952), pp. 535–538.
- Koller, Monica; Walla, Peter (2012): Measuring Affective Information Processing in Information Systems and Consumer Research-Introducing Startle Reflex Modulation. In Proceedings of the International Conference on Information Systems (ICIS).
- Jercic, Petar; Astor, Philipp J.; Adam, Marc T. P.; Hilborn, Olle; Schaaff, Kristina; Lindley, Craig et al. (2012): A serious game using physiological interfaces for emotion regulation training in the context of financial decision-making. In Proceedings of the 20th European Conference on Information Systems (ECIS), pp. 1–14.
- Peffers, Ken; Tuunanen, Tuure; Rothenberger, Marcus A.; Chatterjee, Samir (2008): A design science research methodology for information systems research. In Journal of Management Information Systems 24 (3), pp. 45–77.
- Riedl, René; Kindermann, Harald; Auinger, Andreas; Javor, Andrija (2012): Technostress aus einer neurobiologischen Perspektive. In Wirtschaftsinformatik 54 (2), pp. 59–68.
- Smith, Vernon L. (1982): Microeconomic systems as an experimental science. In The American Economic Review 72 (5), pp. 923–955.
- vom Brocke, Jan; Riedl, René; Léger, Pierre-Majorique (2013): Application strategies for neuroscience in information systems design science research. In Journal of Computer Information Systems 53 (3), pp. 1–13.

Truth Detection: Unbiased Brain Responses Reflecting Brand Attitude

Peter Walla, School of Psychology, Functional Neuroimaging Lab, University of Newcastle; Centre for Translational Neuroscience and Mental Health
Monika Koller, Department of Strategic Management, Marketing and Tourism, University of Innsbruck School of Management, Innsbruck, Austria; Department of Marketing, Vienna University of Economics and Business, Vienna, Austria
Shannon Bosshard, School of Psychology, Functional Neuroimaging Lab, University of Newcastle
Corresponding author: peter.walla@newcastle.edu.au

Human behaviour is driven by conscious (or explicit) as well as non-conscious (or implicit) neural information processing in the brain. To better understand and also predict human behaviour researchers take measures that are assumed to be directly correlated with it while exposing their study participants with various different stimuli or asking them any questions.

Crucially, explicit decisions and/or explicit responses to asked questions are not always directly reflective of actual behaviour. For example, just because people say (or tick a box) that they always buy eco-friendly (or organic) food doesn't mean they actually do it. However, traditional research approaches in product development, marketing and advertising usually follow the idea that explicit responses form a reliable basis to shape products, marketing strategies or the design of an ad. This is in clear contrast to what recent empirical evidence would suggest one to do. Grahl et al. (2012) found gender-specific discrepancies between explicit and implicit responses to different bottle shapes. Geiser and Walla (2011) found that walking through virtual urban environments elicits implicit emotional responses that differ from explicitly stated preferences. Also food intake (Walla et al., 2010), viewing facial expressions (Dunning et al., 2010) and even simply looking at emotional scenes are associated with such discrepancies (Mavratzakis et al. (2013).

Given all the above-mentioned evidence we were highly motivated to test whether or not an implicit measure, in this case brain activities in the form of neural potential changes (event-related potentials; ERPs), are directly reflective of brand attitude as in like and dislike towards known brands.

For this purpose we invited participants to first take part in the initial phase of our experiment, during which they were required to complete a survey and rate their attitude towards 300 brand names. After having recorded these ratings, an individual brand list was created for each participant. In the second phase of the experiment, participants were required to enter the laboratory and view all brand names again while brain potentials were recorded via electroencephalography (EEG). After adequate statistical analysis we found that brands that were rated more positively (via self-report) were seen to elicit less negative brain potentials over the right frontal hemisphere than brands that were rated negatively. First of all, this result strongly confirms the usefulness and reliability of objective measures to investigate marketing-relevant attitudes as in likes and dislikes related to brand names. Second, it also provides an important basis for future investigations that will be designed to demonstrate the effect of evaluative conditioning on attitudes, a widely used tool in marketing and advertising. Finally, the present findings support the idea that basic affective processing as in brand attitudes is accessible via EEG (see Walla&Panksepp, 2013)

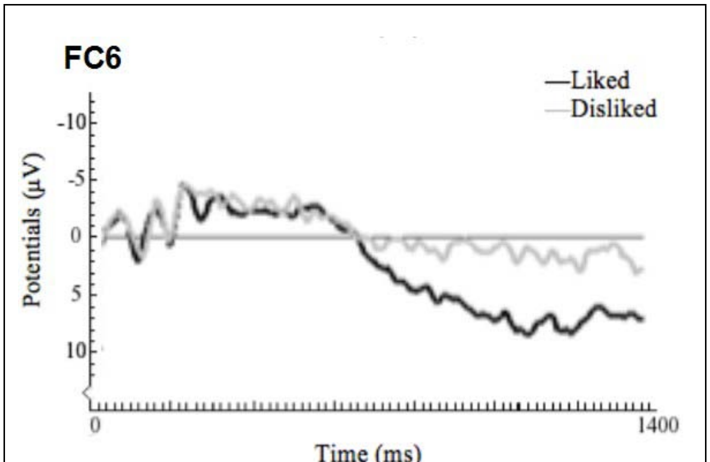


Figure 1. Event-related potentials elicited during exposure to written brand names that differed with respect to prior stated attitude.

REFERENCES

- ❖ Dunning JP, Auriemmo A, Castille C, Greg H.(2010). In the face of anger: Startle modulation to grade facial expressions. Psychophysiology, 47: 874–878.
- ❖ Geiser, M., Walla, P. (2011). Objective measures of emotion during virtual walks through urban environments. Applied Sciences, 1: 1-11.
- ❖ Grahl, A., Greiner, U., and Walla, P. (2012). Bottle-shape elicits gender-specific emotion: a startle reflex modulation study. Psychology, 3(7): 548-554.
- ❖ Mavratzakis, A., Molloy, E., and Walla, P. (2013). Modulation of the Startle Reflex during Brief and Sustained Exposure to Emotional Pictures. Psychology 4 (4), 389-395.
- ❖ Walla, P., Richter, M., Färber, S., Leodolter, U., and Bauer, H. (2010). Food-evoked Changes in Humans: Startle Response Modulation and Event-related Brain Potentials (ERPs). *Journal of Psychophysiology* 24, 25-32.
- ❖ Walla, P., Brenner, G., and Koller M. (2011). Objective measures of emotion related to brand attitude: A new way to quantify emotion-related aspects relevant to marketing. *PLoS ONE* 6(11), e26782. doi:10.1371/journal.pone.0026782.
- ❖ Walla, P., and Panksepp, J. (2013). Neuroimaging Helps to Clarify Brain Affective Processing Without Necessarily Clarifying Emotions, Novel Frontiers of Advanced Neuroimaging, Prof. Kostas Fountas (Ed.), ISBN: 978-953-51-0923-5, InTech, DOI: 10.5772/51761. Available from: http://www.intechopen.com/books/novel-frontiers-of-advanced-neuroimaging/neuroimaging-helps-to-clarify-brain-affective-processing-without-necessarily-clarifying-emotions”

The Potentials of Neuroscience Methods for Business Process Modeling Tools

Maria Shitkova, Justus Holler, Jörg Becker, University of Münster - ERCIS

Corresponding author: maria.shitkova@ercis.uni-muenster.de

Neuroscience methods have already been recognized as a powerful mechanism for human-computer interaction research (Riedl et al. 2010). These methods provide instruments for detecting the user emotions based on the reactions of human nervous system. In this paper we explore the potentials of integrating neuroscience methods for detecting emotions in business process modeling (BPM).

Strong emotions, such as stress, can on the one hand negatively affect the work performance (Laborde et al. 2013; Lazarus 2000), and on the other hand can also be an indicator of the user attitude to the information system she is using at the moment (Albert and Tullis 2013). Thus we see two possible application scenarios for the case of BPM tools. The first scenario is closely connected to the decrease in work performance and quality of work results, when the user is experiencing strong emotions. Thus if it is possible to detect user emotions when she is creating process models, it will be also possible to *predict the quality of created BPM models* (S1) (Heide et al. 2014). The second scenario presupposes that user emotions may be caused by the computer program she is interacting with at the moment (e.g. inefficient or unsatisfactory program functions often cause stress (Albert and Tullis 2013)). Tracking user emotions may help to identify potential problems in the software and thus *continuously improve BPM tool usability* (S2). We further present a concept of integrating neuroscience methods into a BPM tool for detecting user emotions and discuss both application scenarios in detail.

The proposed concept is based on the BPM tool icebricks (Becker et al. 2013). The tool provides a possibility to model and analyse business process models for arbitrary business domains. The existing icebricks architecture can be described as a simple process model repository together with a web-based modeling environment and user profile. In order to incorporate the neuroscience methods into the BPM tool we extend this architecture with neuro-sensors and an analytical assessment mechanism for detecting user emotional condition as shown in Figure 1. User profile and process model repository will also be extended to store user emotions data in order to satisfy the requirements of the concept.

To detect user emotions particular measurement devices have to be used. Two main groups of measurement tools exist in neuroscience: brain-imaging tools and psychophysiological tools, also called lightweight solutions (Loos et al. 2010). The first group of the tools tracks the activity of different brain areas using electroencephalography (EEG), functional magnetic resonance imaging (fMRI), positron emission tomography (PET) and other rather complicated devices. These tools are difficult to integrate into "real-world" information systems (IS) applications, because they are not flexible with respect to time (when can participants use the system?) and space (where can participants use the system?) and thus using this kind of measurement devices leads to an artificial working environment. The second group of tools is the oldest and simplest techniques to measure somatic states by capturing indicators closely related to the nervous system (e.g. facial emotional response (EMG), skin conductance response (SCR) or eye tracking) (Loos et al. 2010). This second group can more easily be integrated or applied in IS areas.

As the proposed concept requires an emotion measurement tool, which seamlessly integrates into the working environment, does not distract the user from performing the tasks or create any discomfort, the usage of lightweight solutions is a good trade-off between accurateness and effort (Adam et al. 2011). Following the studies (Adam et al. 2011; Albert and Tullis 2013; Kreibig 2010) the measures of heart rate (HR), heart rate variability (HRV) and skin conductance level (SCL) were chosen to detect the user emotional arousal. Under stress the HR and SCL indicators tend to increase, while HRV decreases.

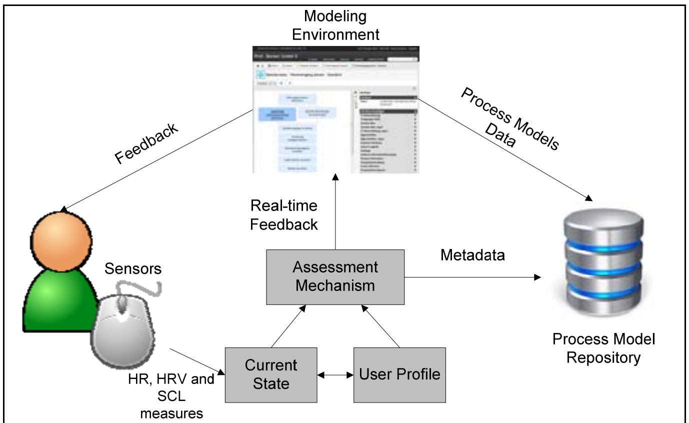


Figure 1. Architecture

A Shark-fin Mouse, proposed by (Christy and Kuncheva 2013) is a possible alternative to the standard HR and SCL monitors, which normally has to be attached to the fingers, wrist or chest, which might cause inconvenience to the user. It is a fully functional computer mouse, which streams pulse and skin conductance data in real-time. We propose this kind of device to be used in our concept.

In order to define the current emotional state of the user, the user profile has to be extended with baseline and threshold values of HR, HRV and SCL. The baseline values define the normal emotional state for the user, while the threshold values reflect the levels of HR, HRV and SCL at which the user is expected to be in a strong emotional state and to potentially produce work results of poor quality. The initial baseline values can be measured when creating the user profile. The threshold values can initially be set to the baseline values and then adjusted as the user interacts with the system.

The assessment mechanism detects the current emotional state of the user and classifies the state as either influencing the quality of the work results or not. The current emotional state of the user contains the aggregated measures of HR, HRV and SCL. Due to the usage of sensors embedded in a computer mouse the HR, HRV and SCL measures can only be collected when the user touches the mouse. This results in the following sets of measures $HR=\{HR_0,\ldots,HR_n\}$, $HRV=\{HRV_0,\ldots,HRV_n\}$ and $SCL=\{SCL_0,\ldots,SCL_n\}$. The indexes $\{0, \ldots, n\}$ represent the intervals when the measurement took place (e.g. each time the user touches the mouse), HR_i, HRV_i and SCL_i are the average heart rate, heart rate variability and skin conductance level values taken during one of the several measuring intervals.

The process model repository is extended to keep the trace of the users' actions and emotion measurement data during to the session along with the process models data created. The trace of user actions and emotion measurement data serve as metadata for the process models. All the entries are synchronized using timestamp values and can later be used for usability evaluation (S2).

The assessment mechanism then compares the current emotional state to the user's threshold values in order to define the presence of strong emotions (e.g. stress). The assessment results are also stored as metadata together with the created models and can be later used for predicting the quality of created models (S1).

As presented above we have defined two potential scenarios for using the neuroscience measures in BPM tools, which we discuss in the following part of the paper.

S1 – predicting quality of process models (Heide et al. 2014).

The quality of business process models created in a modelling project is of high importance and has to be constantly monitored and assured during all phases of the project (Becker et al. 2011). Emotions such as stress affect general work performance of the user, and thus also the results of process modeling (Laborde et al. 2013; Lazarus 2000). The major problem is however, that as soon as the process model is stored in the process repository, the emotional context is lost and it becomes difficult to detect the quality a posteriori. The artefact is then used without reflexion, which may lead to misinterpretation. Thus the task of storing the emotional data together with the artefact is crucial for quality prediction.

By using assessment mechanism to detect the presence of stress, the quality indicator *(QI)* can be set automatically for any created or updated process model by using the following rule:

$$\text{if } \max_{i=0,n} HR_i \geq HR_{TR} \text{ or } \min_{i=0,n} HRV_i \leq HRV_{TR} \text{ or } \max_{i=0,n} SCL_i \geq SCL_{TR}$$

then *QI="Potentially Poor"*, else *QI="Potentially Good"*,

where $\max_{i=0,n} HR_i$, $\min_{i=0,n} HRV_i$ *and* $\max_{i=0,n} SCL_i$, are the "worst case" measures of heart rate, heart rate variability and skin conductance level for the current session. Basically each time when the "worst case" measures exceed the threshold value it is assumed that the user has experienced stress during work and the work results are considered to be potentially of poor quality. The "worst case" scenario is used as reference value in order to minimize the number of false positive predictions.

The quality indicator can then be used for moderation of created process models. If the QI is set to "Potentially Poor" the process model will be hidden from other BPM tool users and has to be checked by the author or by his or her colleague or supervisor. Thus the quality of the models inside the BPM repository is constantly monitored and it is assured that the overall quality of models available for the users is always sufficient.

In case the moderation takes place, the threshold values are refined afterwards. If the quality was predicted wrong by the assessment mechanism, new threshold values of HR, HRV and SCL are set to the averages between the old threshold values and the "worst case" current state measures. Thus over time the system learns the user emotional indicators and the threshold values are adjusted to correctly predict the quality.

S2 –continuous usability evaluation of the BPM tool

Stress is also seen as an indicator of poor usability of the tool the user is interacting with, and thus can be used in usability testing (Albert and Tullis 2013). In the concept proposed in this paper the BPM tool is tracking the user actions and saves the respective data as part of the

process models in the database together with the emotion indicators – HR, HRV and SCL.
This data can then be analysed in detail in order to identify the functionality of the tool, which needs improvement. By looking at the highest HR and SCL and lowest HRV values, it can be concluded that the particular functionality used at this moment is not fully understandable by the user or difficult to use, thus causing stress. This functionality can then be evaluated in detail by conducting additional usability tests and gathering quantitative (performance) and qualitative (satisfaction) usability metrics.

Traditional usability testing approaches usually are carrying out experiments with test participants, gather performance data and conduct interviews or surveys. In case of BPM tools this can be rather time consuming, because of the complex functionality of BPM tools. In the proposed approach the neuroscience mechanisms are seamlessly integrated into the working environment and provide the usability assessment data while the user interacts with the system. Thus it is possible to continuously assess the usability level of the application and improve the problematic functionality. After a certain amount of time the users will eventually interact with all the functions in the tool and thus the complete functionality will be tested for usability.

Other possible application scenarios

Another application scenario might be providing live feedback for the user on the current emotional state. The modeling environment should be extended with an emotional indicator, which warns the user when she is potentially stressed. With the help of the indicator the user's attention is called to his current emotional state. Based on the automatic and constant feedback, the user can decide to take a break or to postpone the knowledge work and may switch to activities less affected by the emotional condition. This improves the work results of the user in the short term and strengthens the user's awareness for emotions, thus preventing such illnesses as burnout, in the long term.

The proposed concept of integration of neuroscience methods into BPM tools provides us with the possibility of fostering the overall quality of process models stored in the repository and continuously test and improve the usability of the tool.

One of the drawbacks of the proposed conceptual solution is the limited number of emotional measures (only HR, HRV and SCL) and rather simple rules for detecting the presence of strong emotions. It is also difficult to recognize exact emotions (positive or negative) as different mental events can produce nearly identical physical responses (Kreibig 2010). We believe there is a possibility to extend the concept by incorporating further measurement methods, e.g. pupil dilations (Albert and Tullis 2013), and more sophisticated assessment mechanisms in order to better detect the presence of stress.
In future work we plan to prototypically implement the proposed concept and conduct a set of experiments to prove its applicability.

References

- Adam, M. T. P., Gamer, M., Krämer, J., and Weinhardt, C. 2011. "Measuring Emotions in Electronic Markets," in International Conference on Information Systems, Shanghai, pp. 1–19.
- Albert, B., and Tullis, T. 2013. Measuring the user experience: collecting, analyzing, and presenting usability metrics, Elsevier Inc.
- Becker, J., Clever, N., Holler, J., and Shitkova, M. 2013. "icebricks - Business Process Modeling on the Basis of Semantic Standardization," in Proceedings of the Design Science Research in Information Systems and Technologies (DESRIST), Helsinki.
- Becker, J., Kugeler, M., and Rosemann, M. 2011. Process Management: A Guide for the Design of Business Processes, (2nd ed.) Berlin: Springer, p. 596.
- Christy, T., and Kuncheva, L. I. 2013. "AMBER Shark-Fin : An Unobtrusive Affective Mouse Input Modalities for Affective Computing," in ACHI 2013, The Sixth International Conference on Advances in Computer-Human Interactions, Nice, France, pp. 488–495.
- Heide, T., Shitkova, M., and Becker, J. 2014. "NeuroKMS Integrating Neuroscience into Knowledge Management for Assuring Data Quality," in Proceedings of the Multikonferenz der Wirtschaftsinformatik, Paderborn, pp. 1965–1977.
- Kreibig, S. D. 2010. "Autonomic nervous system activity in emotion: a review.," Biological psychology (84:3), pp. 394–421.
- Laborde, S., Raab, M., and Dosseville, F. 2013. "Emotions and Performance: Valuable insights from the sports domain," in Psychology of Emotions, (Vol. 38) Nova Publisher.
- Lazarus, R. S. 2000. "How Emotions Influence Performance in Competitive Sports," The Sport Psychologist (14:3)Human Kinetics, pp. 229–252.
- Loos, P., Riedl, R., Müller-Putz, G. R., vom Brocke, J., Davis, F. D., Banker, R. D., and Léger, P.-M. 2010. "NeuroIS: Neuroscientific Approaches in the Investigation and Development of Information Systems," Business & Information Systems Engineering (2:6), pp. 395–401.
- Riedl, R., Randolph, A. B., vom Brocke, J., Léger, P.-M., and Dimoka, A. 2010. "The Potential of Neuroscience for Human-Computer Interaction Research," in SIGHCI 2010 Proceedings.

Identifying Goal-oriented and Explorative Information Search Patterns

Jella Pfeiffer, J. G. Univ. Mainz, Martin Meißner, SDU, Jascha Prosiegel, J. G. Univ. Mainz, Thies Pfeiffer, Bielefeld Univ.

Corresponding author: jella.pfeiffer@uni-mainz.de

I. Introduction

One of the latest trends of ubiquitous Information Systems is the use of smartglasses, such as Google Glass or Epson Moverio BT-200 that are connected to the Internet and are augmenting reality with a head-up display. In order to develop recommendation agents (RAs) for the use at the point of sale, researchers have proposed to integrate a portable eye tracking system into such smartglasses (Pfeiffer et al. 2013). This would allow providing the customer with relevant product information and alternative products by making use of the customer's information acquisition processes recorded during the purchase decision.

To make a meaningful recommendation to the customer at the point of sale at the right moment, the RA must be able to detect the decision situation the customer is in which is crucial to determine the required information (Huschens et al. 2014, Moe 2003). As a first step towards building an RA, this paper investigates differences in information search patterns between goal-directed and exploratory purchase situations in which an immediate purchase is intended (Moe 2003, Janiszewski 1998). In goal-directed situations customers will be in need of more goal-related information, like product alternatives that best fit to their individual preferences. In order to find a product which fits their specific needs customers will have to search for detailed product attribute information. For example, they might search for a muesli which includes almonds and chocolate but is of low calories. In an explorative situation, however, customers should be primarily focused on scanning and gathering information about the products available. Based on previous findings, we hypothesize that customers will be less interested in specific information about product attributes, e.g. details concerning the ingredients, but search more for brand- or price-related information.

The work presented here is part of a larger project where we intend to build an RA into smartglasses with eye-tracking capability that can automatically detect the kind of decision situation the customer is in and provide recommendations accordingly. This paper provides first results how eye tracking information can be used to identify goal-oriented and explorative information search patterns. In a first step, we analyse which characteristics of the gaze behaviour can potentially be used to differentiate between the two situations. In a second step, we then use a simple logistic regression analysis to predict whether respondents were in a goal-oriented or explorative condition.

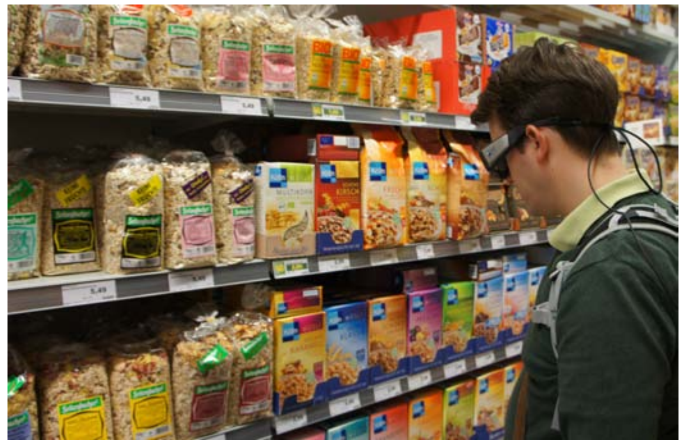


Figure 1. Mobile recommender agents in smartglasses could provide support in decisions at the point-of-sale.

II. Literature Review

Marketing researchers have been especially interested in investigating the in-store and out-of-store factors which influence visual attention and choice. In-store factors are, for example, the number and position of shelf-facings. Important out-of-store factors are past brand usage, the brand's market share as well as demographic criteria and shopping goals. Chandon et al. (2009) examine the interplay between in-store and out-of-store factors on consumers' attention and evaluation processes. They investigated the respective effects for established and new brands which were presented in supermarket shelves. These shelves, however, were simply displayed on a computer screen and stationary (remote) eye tracking equipment was used to record consumers' attention. This setup makes the recorded attentional processes less realistic compared to tracking respondents eye movements at the point-of-sale, as depicted in Figure 1.

Gidlöf et al. (2013) were among the first who investigated the attentional processes of consumers in a more natural decision environment. These researchers were particularly interested in understanding the different stages of the decision process and comparing these stages with previous studies which have used remote eye tracking equipment. They argue that the eye movements are strongly affected by the structure of the task environment which makes it relevant to study search processes in more natural decision situations. Moreover, one main finding of this study is that decision-making tasks were substantial different from search tasks, for example with respect to the number of re-dwells in the second stage of the decision process. Gidlöf et al. (2013) conclude that the "most characteristic feature of decision making is in the use of re-fixations and re-dwells" (p.11).

Janiszewski (1998) argues that contrasting goal-directed and exploratory visual search is of major interest when trying to understand the influence of display characteristics on attention. In line with the goal of getting a better understanding how goal-oriented and explorative information search are different, we suggest to use eye tracking for closely monitoring consumers' attentional processes at the point-of-sale because distinguishing between goal-directed and exploratory behaviour helps to identify the customers' motivation and information needs (Huschens et al. 2014, Moe 2003).

III. Experimental Setup

In an experiment we gave respondents the task of either exploring the product alternatives in the shelf or searching a product that matched to pre-specified product characteristics. The study was conducted in a real world setting, i.e. in a medium-sized supermarket, using mobile eye-tracking equipment. Twenty shoppers were recruited directly after entering the store and they received 10€ as incentive for participation. The mean age in the sample was 31.3 (standard deviation (std.) = 13.27, maximum 53 years) and 70% were female.

Every respondent had to search information for four different product categories. We chose muesli, cereals, marmalade and tea as product categories. The number of products available for each category was 116, 76, 202, and 190, respectively. For each product category the participant was either assigned to a goal-oriented task (GT) or an exploratory task (ET), yielding a group size of ten respondents for each of the four decisions tasks, and two GT and two ET per respondent. In each group, respondents were first read out the task description and then the experimenter ensured that participants had understood the task. In the GT task and the muesli condition, participants were told to select a muesli for a friend who would come for a visit. In that scenario, the friend likes to have a muesli which (1) contains chocolate, (2) contains almond, (3) is as low in calories as possible. In the GT for cereals, the required criteria were (1) contains cinnamon, (2) package smaller than 400 grams, (3) is low in calories. In the marmalade GT, participants were told to look for a marmalade that (1) contains orange, (2) contains at least one additional other flavor and (3) is low in price/kg. In the tea group, the requirements were: (1) is organic, (2) contains peppermint, (3) low price per 100 grams. In each category the number of products fulfilling the first two criteria was eight, two, six, and two respectively. There was exactly one optimal product per category that fulfilled all three criteria. In the ET, participants were asked to gain a fairly good overview about the muesli (cereal, marmalade or tea) assortment and to determine criteria which are important for them when buying the product. Afterwards, they had to choose one product they would potentially buy themselves.

During the tasks, participants wore the SMI Eye Tracking Glasses. 80% of the participants regarded the equipment as not distracting, while 20% regarded it as partially distracting and none as distracting.

IV. Results

Figure 2. Scanpath patterns differ significantly during exploratory (dark grey, participant 04) and goal-oriented (light gray, participant 07) Information Search.

Table 1 shows different measurements describing the gaze behaviour in the two different purchase situations. For example, in 4.29% of the time that the GTs took, participants looked at *price* tags, while in the ETs that percentage almost doubled to 8.12%. *Details* describes the proportion of time respondents looked at detailed information like the ingredients and any other texts that were provided on the packages (excluding pure brand information). In the GT respondents on average fixated 144 products (*fixations*), including refixations on the same product (see Figure 2 for an example). Overall, the number of *refixations* (78 on average) in the GT is much higher than in the ET. *Distance* measures the average distance between two fixations on different products in cm. We can see that the distance is only slightly lower for the GT (43.12cm vs. 44.97cm). Overall participants in the GT spend more *time per product*, which sums up the amount of time that participants looked at each product (including refixations).

Table 1. Results with std. in parentheses

	Goal-oriented	Explorative
Price	4.29% (4.23)	8.12% (7.26)
Details	29.78% (17.65)	8.36% (13.16)
Fixations	144 (129)	97 (64)
Refixations	78 (97)	40 (38)
Distance	43.12cm (19.58)	44.97cm (14.39)
Time per product	1.75 sec (0.93)	0.82 sec (0.40)

We conducted a principal component analysis (PCA) of the eye tracking variables depicted in Table 1 with orthogonal rotation (varimax rotation). Because the Kaiser-Meyer Olkin criterion (KMO) was not met when first including all 6 variables, we excluded *Distance* (based on the measure of sampling adequacy (MSA)) and ran the PCA with the remaining 5 items. The KMO verified the sampling adequacy for the analysis, KMO=0.53. The MSA value was above the acceptable threshold value of 0.5 for all variables included. Moreover, Bartlett's test of sphericity is significant ($\chi^2(10)=267.79$, $p<0.01$) and therefore recommends that the dataset is suitable for factor analysis. We extracted factors with an Eigenvalue larger than 1. Together the two extracted factors explain 78.35% of the total variance.

Fixations and *Refixations* have high positive factor loadings on the first extracted factor (see Table 2). This factor thus represents the general attentional effort of respondents in a task. *Details* and *Time per product* have positive factor loadings on the second factor and *Price* has a negative factor loading. We interpret the second factor as how intensively respondents study the details of the product. If respondents looked more at price information, they also looked less at details which is the reason for the negative factor loading of *Price*.

Table 2. Rotated component matrix

	Factor 1	Factor 2
Price	0.004	-0.595
Details	-0.027	0.900
Fixations	0.986	0.043
Refixations	0.987	0.098
Time per product	0.401	0.795

Subsequently, we used a logistic regression model with standardized *Refixations* and *Details* as explanatory variables because they load highest on the two factors that we identified. With this model, we predict whether the respondent is in a goal-oriented situation (0) or an exploratory situation (1). The results are shown in Table 3 for 68 observations. 12 observations are missing because of technical problems with the USB-port during gaze recording. The results show that the more details are observed by the respondents the lower the likelihood that this respondent is an exploratory situation. The coefficient for Refixations is negative as well but with $p=0.12$ not significant. A random-effect model that would take into account that we have four observations per participant did not improve the model.

We used 10-fold cross-validation (Kohavi 1995) to estimate the accuracy of the prediction model. Cross-validation randomly divides the data set into equal-sized sub-sets called folds and repeatedly uses them for performance testing. Thus in our case we ten times predict seven out of the cases with an estimation based on the remaining cases. We achieve an average accuracy over the ten folds of 75.24% with a std. of 9.13%. Thus, we are able to differentiate between the two purchase situations in about ¾ of cases which is much higher than pure guessing.

Table 3. Logistic Regression Estimation Results. $^{**}p<0.01$

	Model
Refixations	-0.63 (0.41)
Details	-1.47 (0.36)**
Log likelihood	-32.57
N	68
McFadden R^2	0.31

V. Conclusion

One of the key challenges for developing RAs for use at the point-of-sale is determining customer's intentions. First results show that the attentional effort (the number of fixations and refixations) but even more the level of processing detailed information could be used as indicators of explorative or goal-directed search. Future research should investigate other eye tracking measures in detail to understand which measures are best suited for this purpose. A major challenge lies in tracking and analyzing these eye tracking measures while respondents are processing the information (on-the-fly) in order to be able to give recommendations based on consumers' individual information needs.

References

- Chandon, P., Hutchinson, J. W., Bradlow, E., and Young, S. H. 2009. "Does In-Store Marketing Work? Effects of the Number and Position of Shelf Facings on Brand Attention and Evaluation at the Point of Purchase," *Journal of Marketing* (73), 1-17.
- Gidlöf, K., Wallin, A., Dewhurst, R., and Holmqvist, K. 2013. "Using Eye Tracking to Trace a Cognitive Process: Gaze Behaviour During Decision Making in a Natural Environment," *Journal of Eye Movement Research* (6:1), pp. 1-14.
- Huschens, M., Pfeiffer, J., and Pfeiffer, T. 2014. "Important Product Features of Mobile Decision Support Systems for In-Store Purchase Decisions: A User-Perspective Taking into Account Different Purchase Situations", *Proceedings of the MKWI, Paderborn*, February, pp. 26-28.
- Janiszewski, C. 1998. "The Influence of Display Characteristics on Visual Exploratory Search Behavior," *Journal of Consumer Research* 25(3), pp. 290–301.
- Kohavi, R. 1995. "A Study of Cross-Validation and Bootstrap for Accuracy Estimation and Model Selection", *Proceedings of IJCAI*, 14(2), Montreal, Quebec, pp. 1137-1143.
- Moe, W. 2003. "Buying, Searching, or Browsing: Differentiating Between Online Shoppers Using In-Store Navigational Clickstream", *Journal of Consumer Psychology* (13:1-2), pp. 29–39.
- Pfeiffer, T., Pfeiffer, J., Meißner, M. 2013. "Mobile Recommendation Agents Making Online Use of Visual Attention Information at the Point of Sale", *Proceedings of Gmunden Retreat on NeuroIS (Abstract), Gmunden*, Austria, June, 1-4. 2013

The Treadmill Desk: Sitting Could Kill You, but Can You Walk and Work Well?

Élise Labonté-LeMoyne, HEC Montreal, Radhika Santhanam, The University of Oklahoma, Pierre-Majorique Léger, HEC Montreal, François Courtemanche, HEC Montreal, Sylvain Sénécal, HEC Montreal

Corresponding author: elise.labonte-lemoyne@hec.ca

Information Technology (IT) has greatly contributed to the increase in labor productivity in recent decades (Tambe et al., 2012). The downside is that workers now spend most of their working time sitting at their desks while they work on their IT consoles. Research findings indicate that time spent by employees sitting in front of their consoles is directly related to increased risk of cardiovascular diseases, diabetes, and musculoskeletal pain, and importantly, contributing to an increased risk for death (van der Ploeg et al., 2012). Groups, including the American Heart Association and the American College of Sports Medicine, have appealed for a change in public policy to decrease the number of daily hours spent by employees on this type of sedentary work.

One of the solutions proposed is through the use of a treadmill desk that can reduce the sitting time (http://goo.gl/FYFxsv). With this, workers can walk at low speeds while performing their regular tasks (e.g., make telephone calls, write reports or send email). Studies show that this practice of walk-and-work could have a positive impact on employee health, including weight loss, and improved cholesterol profiles, (Levine et al., 2007). In addition, improving the health of workers leads to other societal benefits, such as lower medical costs and reduced absenteeism from work (Aldana et al., 2001).

The promise of better health is predicted, but the current adoption and research on the impact of this device is sparse. Some early research suggests that there is no impact of the use of a treadmill desk on basic computer interactions (e.g., reaction time with the mouse, typing rhythm; Alderman et al., 2013), but no study has investigated the effect of the device on the cognitive abilities of employees, their performance on complex tasks, and their work perceptions.

Given the important potential health benefits associated with the use of this device, and a dearth of research investigating its impact on employees' performance, the objective of the current study is to investigate the influence of using a treadmill desk (vs. sitting down) on IT employees' cognitive abilities, their performance and perceptions.

We report on an ongoing lab experiment with 20 participants. In this study, subjects had to perform an office task during 40 minutes (i.e., reading a text and managing emails). Half of these participants performed this in a seated position, while the other half performed it while walking at 2.25 km/h using a treadmill desk. At the end of the task, cognitive abilities of the participants were evaluated. We first looked at memory retention (with true or false questions based on the text and emails; Léger et al., 2014), while measuring the participants' cognitive fatigue with EEG (Cao et al., 2014). Second, we evaluated executive functions with EEG during a Tower of London test (Krikorian et al., 1995). Finally, self-perceived attitude toward the task was captured with a survey.

This poster will present preliminary results from the experiment. This study will be followed by a larger scale experiment in October 2014 with equipment and tests to measure attention and self-efficacy during the use of the treadmill desk as well as the effects of multi-day use.

References

- Alderman, B. L., Olson, R. L., and Mattina, D. M. 2013. "Cognitive Function During Low Intensity Walking: A Test of the Treadmill Workstation," *Journal of Physical Activity and Health*.
- Tambe, P., and Hitt, L. M. 2012. "The Productivity of Information Technology Investments: New Evidence from IT Labor Data," *Information Systems Research*.
- van der Ploeg, H. P., Chey, T., Korda, R. J., Banks, E., and Bauman, A. 2012. "Sitting Time and All-Cause Mortality Risk in 222 497 Australian Adults," *Archives of Internal Medicine* (172:6), pp. 494-500.
- Levine, J. A., and Miller, J. M. 2007. "The energy expenditure of using a "walk-and-work" desk for office workers with obesity," *British Journal of Sports Medicine* (41:9), pp. 558–561.
- Léger, P.M., Senecal, S., et al. 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.*
- Aldana, S. G., and Pronk, N. P. 2001. "Health Promotion Programs, Modifiable Health Risks, and Employee Absenteeism," *Journal of Occupational and Environmental Medicine* (43:1), pp. 36.
- Cao, T., Wan, F., Wong, C. M., da Cruz, J. N. and Hu, Y. 2014 "Objective evaluation of fatigue by EEG spectral analysis in steady-state visual evoked potential-based brain-computer interfaces," *Biomedical Engineering Online* (13:1).
- Krikorian, R., Bartok, J., & Gay, N. 1994. "Tower of london procedure: A standard method and developmental data," *Journal of Clinical and Experimental Neuropsychology* (16:6), pp. 840-850.

Parkinson Patients' Trust in Avatars: Implications for Human-Computer Interaction and Neuroscience

Andrija Javor, Department of Neurology, Linz General Hospital, Gerhard Ransmayr, Department of Neurology, Linz General Hospital, René Riedl, University of Applied Sciences Upper Austria and University of Linz

Corresponding author: andrija.javor@akh.linz.at

Parkinson's disease (PD) is a common chronic and progressive neurodegenerative disease with a median incidence of 14 per 100,000 increasing to 160 per 100,000 in the age group over 65 (Hirtz et al., 2007). These patients suffer from motor symptoms like bradykinesia, resting tremor, rigidity, and impaired postural reflexes (Hughes et al., 1992) and also non-motor symptoms are common, even in early stages of the disease (Aarsland et al., 2009). Cognitive disturbances include the domains of attention, memory and decision-making (Brand et al., 2004). Furthermore, several behavioral disturbances have been reported for PD, such as disturbances related to theory-of-mind (e.g. Yu & Wu, 2013), face recognition (e.g. Dujardin et al., 2004), risk-taking and trust (Javor et al., 2013a).

Patients in general use the computer and the internet for private and disease specific information search and communication (Hartzband & Groopman, 2010). According to a Norwegian study nearly 80% of computer users with Parkinson's Disease report to have significant, severe or highly severe difficulties using a computer (Begnum, 2010). Interacting with computers can lead to a perception of complexity, uncertainty, and stress (e.g., Riedl, 2013), and therefore the question of how to design computer interfaces for patient populations is a major topic in Human-Computer Interaction (HCI) (Biswas & Robinson, 2008). While the effects of PD patients' motor symptoms on their interaction with computers is on the research agenda of HCI scholars (e.g. Keates & Trewin, 2005), behavioral symptoms have hardly been made the subject of discussion in the past.

Avatars are user-created digital representations symbolizing the user's presence in a virtual environment (Bailenson et al., 2005). Several studies have demonstrated that avatars are perceived as social agents, thereby having potential social influence on humans (e.g. Bailenson et al., 2005; Pertaub et al., 2001). Hence, humans interacting with avatars have an experience of being with another person (Bailenson et al., 2005). In line with this research one study showed that avatars are trusted to a similar extent as humans by healthy subjects (Riedl et al., 2014). For these reasons, avatars often occur in the online world to help overcome the above-mentioned perception of uncertainty by imitating face-to-face interaction (Donath, 2007).

There have been first studies to investigate how patients suffering from psychiatric diseases interact with avatars, e.g. in schizophrenia (Park et al., 2009; Castelnovo et al., 2012) and bipolar disorder (Kim et al., 2009), and psychiatry has already started to adopt these findings in order to advance basic and clinical research. However, how neurological patients in general, and PD patients in particular, interact with avatars has, to the best of our knowledge, not yet been studied. This is surprising considering the fact that PD patients frequently encounter avatars in virtual environments in their private lives, but also in diagnostic environments used to examine and evaluate PD patients (Arias et al., 2012), in assistive technologies (Cunningham et al., 2009), and in neurorehabilitation systems (Yu et al., 2011). Furthermore, in the light of the above mentioned deficiencies of PD patients in face-to-face social interaction one might speculate if and how these impairments influence human-avatar interaction. To derive our hypotheses, we argue from a neuroscientific perspective as follows:

(1) PD patients have lower trust in simulated face-to-face interactions compared to healthy controls (Javor et al., 2013a). Because trust is mainly related to activity in three brain regions, namely the limbic system, the basal ganglia and theory-of-mind-regions of the frontal cortex (Riedl & Javor, 2012), and all of these regions are affected by PD, there are several candidates that could be responsible for the trust deficit in face-to-face interaction.
(2) There is evidence that theory-of-mind regions are more active in the evaluation of the trustworthiness of human faces compared to avatars (Riedl et al., 2014). Furthermore, avatars, if compared to humans, elicit less activation in the limbic system (Moser et al., 2007).
(3) Based on consideration of the facts in (1) and (2) we hypothesize that PD patients have less or no trust deficit when interacting with avatars, because some of the brain regions that are affected by PD and which are important for trust regulation are less active in human interaction with avatars.

To test our hypothesis we designed an experiment, where participants played a one-shot trust game against 16 avatars and 16 real faces in the role of the trustor (i.e., investor). We recruited 20 PD patients and 20 healthy controls (matched for gender, age, income and education). While PD patients have lower trust in human faces compared to healthy controls, this study shows no significant difference between PD patients' and healthy controls' trust in avatars. Furthermore, PD patients show higher trust in avatars if compared to their trust in human faces.

A major implication of our study is that avatars could be used in information systems and human-computer interfaces used by PD patients in order to increase their trust. We see the following important application domains: (1) assistive and rehabilitation technologies, (2) specific public health messages for PD patients in social media, and (3) telemedicine. Our study has also implications for e-commerce and suggests that online shops frequently used by PD patients could increase trust by using avatar salespersons. However, Javor et al. (2013b) argued that marketing research involving patients or disabled persons should be strictly evaluated from an ethical point of view.

Human-avatar interaction elicits a brain response that differs from human-human interaction, especially in the amygdala and theory-of-mind regions (Moser et al., 2007; Riedl et al., 2014). Our data shows that there is no difference in trust behavior between PD patients' and healthy controls' interaction with avatars, while there is a trust deficit in PD patients' interaction with humans. This could lead to the hypothesis that the trust deficit of PD patients in face-to-face-interaction could be a consequence of impaired limbic (face recognition) and frontal (theory-of-mind) functions. We advocate for further research using functional brain imaging to gain insights into the pathophysiology of trust in PD patients' interaction with humans and avatars.

References

- Benbasat, I., and Zmud, R.W. 2003. "The Identity Crisis within the IS Discipline: Defining and Communicating the Discipline's Core Properties," *MIS Quarterly* (27:2), pp. 183-194.
- Arias, P., Robles-García, V., Sanmartín, G., et al. 2012. "Virtual reality as a tool for evaluation of repetitive rhythmic movements in the elderly and Parkinson's disease patients," *PloS one* (7:1), e30021.
- Aarsland, D., Brønnick, K., Larsen, J.P., et al. 2009. "Norwegian Park West Study G. Cognitive impairment in incident, untreated Parkinson disease: The Norwegian Park West Study," *Neurology* (72), pp. 1121-1126.
- Bailenson, J. N., Swinth, K., Hoyt, C., et al. 2005. "The independent and interactive effects of embodied-agent appearance and behavior on self-report, cognitive, and behavioral markers of copresence in immersive virtual environments," *Presence: Teleoperators and Virtual Environments* (14:4), pp. 379-393.
- Begnum, M.E.N. 2010. "Challenges for Norwegian PC-Users with Parkinson's Disease–A Survey," In *Computers Helping People with Special Needs* (pp. 292-299). Springer Berlin Heidelberg.
- Biswas, P., & Robinson, P. 2008. "Modelling user interfaces for special needs," *Accessible Design in the Digital World (ADDW)*.
- Brand, M., Labudda, K., Kalbe, E., et al. 2004. "Decision-making impairments in patients with Parkinson's disease," *Behav Neurol* (15), pp. 77-85.
- Castelnovo, A., Ranieri, R., Marcatili, M., et al. 2012. "P-1222-Decision making in schizophrenia: a neuroeconomic trial on social cognition," *European Psychiatry*, (27:1).
- Cunningham, L.M., Nugent C.D., Finlay D.D., et al. 2009. "A review of assistive technologies for people with Parkinson's disease," *Technology and Health Care* (17:3), pp. 269-279.
- Donath, J. 2007. "Virtually trustworthy," *Science* (317), pp. 53-54.
- dos Santos Mendes, F.A., Pompeu, J.E., Modenesi Lobo, A., et al. 2012. "Motor learning, retention and transfer after virtual-reality-based training in Parkinson's disease - effect of motor and cognitive demands of games: a longitudinal, controlled clinical study," *Physiotherapy* (98:3), pp. 217-223.
- Dujardin, K., Blairy, S., Defebvre, L., et al. 2004. "Deficits in decoding emotional facial expressions in Parkinson's disease," *Neuropsychologia* (42), pp. 239-250.
- Hartzband, P., Groopman, J. 2010. "Untangling the Web - Patients, Doctors, and the Internet," *N Engl J Med* (362), pp. 1063-1066.
- Hirtz, D., Thurman, D.J., Gwinn-Hardy, K., et al. 2007. "How common are the "common" neurologic disorders?" *Neurology* (68), pp. 326-337.
- Hughes, A.J., Ben-Shlomo, Y., Daniel, S. E., et al. 1992. "What features improve the accuracy of clinical diagnosis in Parkinson's disease: a clinicopathologic study," *Neurology* (42), pp. 1142-1146.
- Javor, A., Riedl, R., Kirchmayr, M., et al. 2013a. „Trust and risk behavior in Parkinson's disease: Experimental evidence and clinical implications," *Journal of the Neurological Sciences* (333), pp. e80-e81.
- Javor, A., Koller, M., Lee, N., et al. 2013b. "Neuromarketing and consumer neuroscience: Contributions to neurology," *BMC Neurol* (13:1), p. 13.
- Keates, S., Trewin, S. 2005. "Effect of age and Parkinson's disease on cursor positioning using a mouse," In *Proceedings of the 7th international ACM SIGACCESS conference on Computers and accessibility*, pp. 68-75.
- Kim, E., Jung, Y. C., Ku, J., et al. 2009. "Reduced activation in the mirror neuron system during a virtual social cognition task in euthymic bipolar disorder," *Progress in Neuro-Psychopharmacology and Biological Psychiatry* (33:8), pp. 1409-1416.
- Moser, E., Derntl, B., Robinson, S., et al. 2007. "Amygdala activation at 3T in response to human and avatar facial expressions of emotions," *J Neurosci Methods* (161), pp. 126-133.
- Park, I.H., Kim, J.J., Ku, J., et al. 2009. "Characteristics of social anxiety from virtual interpersonal interactions in patients with schizophrenia," *Psychiatry* (72), pp. 79-93.
- Pertaub, D.-P., Slater, M., Barker, C. 2001. "An experiment on public speaking anxiety in response to three different types of virtual audience," *Presence: Teleoperators and Virtual Environments* (11:1), pp. 68-78.
- 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.
- Riedl, R., Javor, A. 2012. "The Biology of Trust: Integrating Evidence from Genetics, Endocrinology and Functional Brain Imaging," *Journal of Neuroscience, Psychology, and Economics* (2), pp. 63-91.
- Riedl, R., Mohr, P., Kenning, P., David, F., Heekeren, H. 2014. "Trusting Humans and Avatars: A Brain Imaging Study Based on Evolution Theory," *Journal of Management Information Systems* (30:4), pp. 83-114.
- Yu, R.L., Wu, R.M. 2013. "Social brain dysfunctions in patients with Parkinson's disease: a review of theory of mind studies," *Translational neurodegeneration* (2:1), pp. 7.

Tracking Information Relevance

Jacek Gwizdka, School of Information, University of Texas at Austin; Michael Cole, Rutgers University

Corresponding author: Jacek Gwizdka: neurois2014@gwizdka.com

Relevance is a fundamental concept in information retrieval. We consider relevance from user perspective (Borlund, 2003) and focus on topical relevance that is described as the extent to which the content of a document (or a set of documents) matches the topic of the query or a user's information need (Saracevic, 2007). Judgments of document relevance are important events during user interaction with a search system. Direct and non-intrusive detection of relevance judgements would provide an objective means to capture this important aspect of user's interaction with information while a user is engaged in search. We continue our work that aims to better understand the concept of relevance in order to better support searchers on their tasks. We report on a project in which we explored the possibility of inferring relevance from eye-tracking data and in which as we asked if reading documents that vary in a degree of relevance to a user's information search goal imposes different cognitive demands.

We conducted an experiment, in which participants were asked to find information in short text documents containing news stories. The experiment was conducted in a usability lab equipped with Tobii T-60 eye-tracker. The experimental design shown in Figure 1 is essentially the same as in our fMRI study reported at NeuroIS'2013 (Gwizdka, 2013). We describe it briefly below. Each participant performed two types of tasks: 1) target word search (WS task), and 2) a simulated information search (IS task). Each session included 21 pseudo-randomized trials of each task type, as well as a few training trials. We focus on reporting results from IS task. The IS task involved finding relevant factual information in news stories. First, general task instructions were presented on screen for 30 seconds, next a fixation screen appeared for 4 seconds, then a question was displayed for 8 seconds. The question instructed participants what information they were expected to find in subsequently presented documents. Twenty one questions were presented in pseudo-randomized order, each followed by three news stories of varied relevance: irrelevant – I, partially relevant texts that were on a question's topic, but did not contain the answer – T, and relevant texts that contained the answer – R (Figure 1). Fixation screens were presented for 4 seconds before each text. In addition, to remind participants of the current question, it was repeated briefly (4s) before the second and third text (shown in Figure 1 as "+" above the stimuli). Participants responded by explicitly judging document relevance of sixty-three news stories on a binary scale (yes/no). Before the actual task began, participants performed a few training trials.

Figure 1. Experimental Design

The documents used in the study came from a large set of news stories obtained from the AQUAINT corpus (Graff, 2002). All news stories were in English and originated from several international sources, such as Associated Press, New York Times, and Xinhua. We selected a subset of stories aiming to achieve a relatively low variation in the text length. We obtained relevance assessments for the documents from TREC Q&A task from 2005 (Voorhees & Dang 2005). We further manually verified the relevance assessments for the selected document subset. The average length of the documents was 178 words (SD=30).

Eye movements were analysed using our reading modelling approach described in (Cole et al., 2011a; 2011b), which is briefly summarized below. Our approach is influenced by the E-Z Reader model (Reichle et al, 2006; Rayner et al, 2011). The assumptions of that model are as follows: 1) reading is serial and words are processed one at a time in the order of their appearance in text, 2) more than one word can be processed on a fixation, because next word can be processed in parafoveal view, and 3) there is a minimum fixation time required for acquisition of a word's meaning. Accordingly, we use fixation duration threshold of 150ms. We implemented a simple, two-state, line-oriented reading model and used it to group these lexical fixations into reading and scanning sequences (Figure 2). A reading state represents reading in one line; reading in the subsequent line is represented by a new reading state. A scanning state represents isolated lexical fixations.

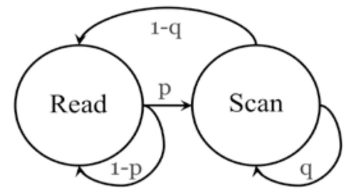


Figure 2. Two-state modeling of reading. p and q are probabilities of transitions between states

To investigate our second research question, we used reading-fixation-sequence based measures that have been suggested as reflecting aspects of cognitive effort (e.g., Rayner et al. 2006; Rayner et al. 2011).

- fixation duration,
- number of regression fixations in the reading sequence,
- the spacing of fixations in the reading sequence (referred to as perceptual span),
- reading speed, a) defined as the length of reading in pixels per unit time, b) as the number of words fixated upon per unit of time, and
- reading length, a) defined as the length of reading in pixels; b) defined as the number of words fixated upon.

We also included reaction time (RT) as a standard measure of cognitive effort. Longer reaction times indicate more effort involved in accomplishing a task. RT was defined in our study as the time from the onset of document presentation to the participant's key press expressing their relevance judgment.

We started by cleaning and pre-processing eye-tracking data. We used only those fixations where the quality of data was good and where fixation was with-in the screen coordinates. Bad quality fixations were defined as missing eye or a low probability of correct acquisition of eye position (as reported by Tobii eye-tracker). This resulted in removing approximately 5% of fixations. We considered all trials in which a participant responded by pressing yes/no, without regard to the correctness of the response. Due to the typically high individual variability of eye-tracking measures, we first personalized measures by calculating z-scores for each user separately. The underlying procedure is similar to personalization of measures described in (Buscher et al. 2012). The procedure effectively removes variability due to an individual.

We performed a series of one-way ANOVA analyses with degree of relevance as independent factor, and examined the effects of relevance on reading vs. scanning, number and duration of reading sequences, fixation duration, regressions, perceptual span and reading length and speed.

Table 1. Probabilities of transition between **reading** and **scanning** states. (S-scanning, R-reading).

Note: Due to lack of homogeneity of variance, we report Welch's corrected F. In all cases p<.001. This applies to all statistics reported in tables.

	I	T	R	ANOVA
SS	**0.52**(.013)	0.46(.013)	0.38(.013)	F(2,809)=37.6
SR	0.47(.013)	0.54(.013)	**0.61**(.013)	F(2,809)=37.2
RR	0.79(.006)	0.84(.006)	**0.88**(.004)	F(2,790)=122
RS	**0.21**(.006)	0.16(.006)	0.12(.004)	F(2,790)=122

Post hoc tests (Games-Howell) indicated that the significant differences were between all pairs of results. The highest probability of reading was for relevant documents. The highest probability of scanning was for irrelevant documents. Topical documents were in the middle (Table 2). Illustrative eye movement patterns for three selected document are shown in Figure 3.

Examining other dependent variables we found that perceptual span, the number of retrograde fixations, and the speed of reading measured in words/time were not significantly different between the document types. However, all other variables differed significantly. We report them below. Table 2 presents eye-tracking variables normalized by the length of documents (in words).

Table 2. Eye-tracking derived variables normalized by the length of documents in words.

Variable	I	T	R
reaction time (RT)	43	71	59
reading length	8.6	16	13
reading speed in px/time	.18	.21	.21
duration of reading	26	47	41
duration of scanning	13	15	9
number of reading sequences	.11	.2	.17
number of fixations on words	25	42	34
total number of fixations	.17	.27	.22

Similarly as reported for Table 1, the post hoc tests (Games-Howell) for results presented in Table 2 indicate that the significant differences were between almost all pairs of results. One exception was the lack of significant difference in reading speed in pixels between topical and relevant documents. Reaction time (normalized to the length of documents in words; Table 2) shows that judging topical documents was most effortful, while judging the irrelevant documents was the easiest. Eye-tracking based measures show a similar pattern (Table 2 and Figure 3), with an exception of reading speed, which indicated that reading irrelevant documents was slower, and reading topical or relevant documents was faster.

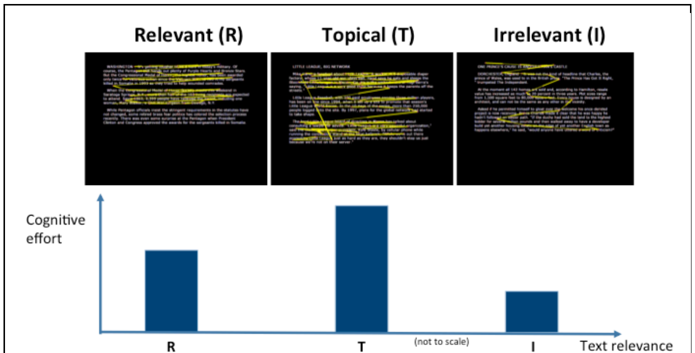


Figure 3. Example eye movement patterns and relationship between text relevance and cognitive effort.

The results obtained thus far show that the degree of relevance of a text document does affect how it is read. Significant differences in reading patterns were found between documents at the three levels of relevance. These findings generally agree with Buscher at el. (2012) in that relevant documents tend to be read more coherently, whereas irrelevant documents tend to be scanned.

The degree of relevance of a text document seems to affect cognitive effort involved in reading it. Reaction time and a collection of eye-tracking based measures indicate that the lowest cognitive effort was involved in judging that a news story is not relevant. Judging topically relevant documents required highest effort, while the effort involved judging relevant documents was generally in the middle. This result agrees with Villa and Halvey (2013), who used subjective workload judgment (NASA TLX) to investigate effort involved in relevance judgment. Their results show the same direction of relationship between effort and judging irrelevant and topical documents. However, they did not find a significant differences in cognitive effort between judging irrelevant and relevant documents. This difference in comparison with our results could be because we used a different and a more sensitive assessment of cognitive effort.

Examining the absolute measures, the duration of the longest reading sequences and the longest fixation in reading sequences (Table 3), we found that they were longest for the relevant documents. This is likely an indication that maximum of cognitive demands (Xie & Salvendy, 2001) were imposed by reading some parts of a relevant document, but that, on the average, the effort involved in processing these documents was lower than involved in processing topical documents. Overall, our results demonstrate that the degree of relevance of a text document does affect how it is read and that it does affect the level of cognitive effort required to read documents. The results indicate that relevant documents tended to be continuously read, while irrelevant documents tended to be scanned. In most cases, cognitive effort inferred from eye-tracking data was highest for partially relevant documents and lowest for irrelevant documents.

Our results largely agree with prior findings. However, our contribution is not just in confirming prior results, but also in extending them to documents with three levels of relevance and to a wider range of information topics. The latter is a likely indication that the relationships are independent of topics.

In this paper, we have reported statistical differences in reading patterns and in cognitive effort between documents of different degrees of relevance. In the follow up work, we will attempt to use our data to classify document relevance. One particularly interesting question will be to examine how much eye-tracking data on a given document is needed to plausibly classify the document's degree of relevance. An information retrieval system that knows perceived document relevance can use this information as implicit relevance feedback (White & Kelly, 2006) and return a document set that closer matches a user's search intent. Future work will also examine eye-tracking measures in relation to correctness of user relevance judgments and will look at dynamic changes of cognitive effort while a user is reading one document, before and after she encounters the relevant words. We will also check what words in relevant documents imposed the highest peak cognitive load demands.

Experiment presented in this paper complements our work on information relevance that employs fMRI (Gwizdka, 2013). At a theoretical level, our fMRI work contributes to better understanding of the multi-dimensional concept of information relevance in terms of investigating what networks of brain activations are associated with relevance judgements. At an applied level, findings from our eye-tracking experiment indicate a possibility of inferring degree of relevance of documents in real-time. We believe that establishing distinctions in brain activity related to information search should lead to a better understanding of the search process and, in combination with more applied eye-tracking approaches, to the design of better search engines.

This work was in part supported by IMLS award #RE-04-11-0062-11 and a Google Faculty Award.

References

- Borlund, P. (2003). The concept of relevance in IR. *JASIST*, 54(10), 913–925.
- Buscher, G., Dengel, A., Biedert, R., & Elst, L. V. (2012). Attentive documents: Eye tracking as implicit feedback for information retrieval and beyond. *ACM TOIS*, 1(2), 9:1–9:30.
- Cole, M., Gwizdka, J., Liu C., Bierig, R., Belkin, N., Zhang, X. (2011a). Task and User Effects on Reading Patterns in Information Search. Interacting with Computers. 23(4), 346-362.
- Cole, M., Gwizdka, J., Liu, C., Belkin, NJ. (2011b). Dynamic Assessment of Information Acquisition Effort During Interactive Search. In proceedings of the 74th Annual Meeting of the American Society for Information Science & Technology (ASIS&T 2011).
- Graff, D. (2002). The AQUAINT Corpus of English News Text, Linguistic Data Consortium, Philadelphia.
- Gwizdka, J. (2013). Looking for Relevance In Bran. Paper presented at the Gmunden Retreat on NeuroIS'2013. June 1-4, 2013. Gmunden, Austria. **Dr. H. Zemlicka most visionary paper award.**
- Rayner, K., Pollatsek, A., Ashby, J., & Jr, C. C. (2011). *Psychology of Reading*. Psychology Press
- Rayner, K., Chace, K. H., Slattery, T. J., & Ashby, J. (2006). Eye movements as reflections of comprehension processes in reading. *Scientific Studies of Reading*, 10, 241–255.
- Reichle, E. D., Pollatsek, A., & Rayner, K. (2006). E-Z Reader: A cognitive-control, serial-attention model of eye-movement behavior during reading. *Cognitive Systems Research*, 7, 4–22.
- Saracevic, T. (1975) . Relevance: A review of and a framework for the thinking on the notion in information science. *Society for Information Science*, 26, 321–343.
- Villa, R., & Halvey, M. (2013). Is relevance hard work?: evaluating the effort of making relevant assessments. *SIGIR'13*. (pp. 765–768). New York, NY: ACM.
- Voorhees, E.M., Dang, H.T. (2005) Overview Of The Trec 2005 Question Answering Track. Nist.
- White, R., & Kelly, D. (2006). A study on the effects of personalization and task information on implicit feedback performance. *CIKM'06*, (pp. 297-306).
- Xie, B., & Salvendy, G. (2000). Prediction of Metal Workload in Single and Multiple Task Environments. *International Journal of Cognitive Ergonomics*. 4(3), 213-242.

Neuroimaging Research in Social Sciences: An Overview

Pankush Kalgotra, Ramesh Sharda, Oklahoma State University, Stillwater, OK, USA

Corresponding author: pankush@okstate.edu

Social cognitive neuroscience research refers to the interactions among analyses at the social, cognitive and neural level (Ochsner and Lieberman, 2001). Although it would appear that there are huge gaps between social science and neuroscience research, some of the interests are common to both disciplines. For example, neuroscience has a rich database on the neural correlates of emotions, stress, aggression, bonding and other social behaviours that are also the constructs of social sciences. Recently, the advancement and feasibility of several neuroimaging tools such as Electroencephalography (EEG), Functional magnetic resonance imaging (fMRI), Near-infrared spectroscopy (NIRS), etc., have led social science researchers to use theories of cognitive neuroscience for their research. Neuroimaging is a reliable and robust method that can help social sciences strengthen their existing constructs and unearth new ones.

Since the last decade, many subfields within the interface of neuroimaging and social science areas have emerged such as neuroeconomics, neuromarketing, neuroIS, neurofinance, neuropolitics, etc. that attempt to make use of neuroscience. Economics and marketing researchers started exploring neuroscience in the early twenty-first century. Other fields such as Information Systems and Finance have followed since. In this paper, we explore the evolutionary trends of social neuroscience research. We will refer to this collectively as neuroSS research. The focus of this paper is to analyze the progress of neuroSS research and compare the emerging subfields. We also study the opportunities for the emerging subfields to use different strategies to enhance their respective fields. We use two methods to explore and discover trends in the social neuroscience literature: bibliometric analysis and text mining. These methods are explained below in our context.

Bibliometrics is defined as "mathematical and statistical analyses of patterns that arise in the publication and use of documents" (Diadato 1994: viii-ix). Verbeek et al. (2002) noted that bibliometric indicators can contain adequate information to assess the performance of a field or researchers in the field. Scientific publications are the principal units of measurement in bibliometrics. The number of research publications (output) indicates the size and progress of research in a field. Similarly, we report on the number of publications over time in each area.

These indicators quantify the research output but do not explain the actual content of the research. We used text mining to learn key trends in the research. Text mining is a process of discovering new and potentially useful information from a variety of unstructured data (Delen & Crossland, 2008). Text mining can be used to make large information corpus more precise, efficient, manageable and comprehensive. It can be used as a simple application like counting the number of a particular word in a document to a more complex application such as in the biomedical field to find protein-protein interaction or protein-disease association from the literature (Ananiadou et al. 2010). Some of the other common applications of text mining are topic tracking, summarizing, clustering, categorization, concept linking and many others to extract knowledge from unstructured data. Text mining is a different approach to analyze and understand previous research.

The volume of publications on any topic in general is increasing rapidly and most papers are now available online as well. A researcher might only use a subset of the literature available, which can result in a low quality study (Delen & Crossland, 2008). There are several repositories available online that have lists of papers on an individual topic, for example, the studies published on the neuroIS can be found on neurois.org. But there is no automated system that can incorporates all the research and divide the knowledge into clusters. In this study, we applied text-mining approach that can help researchers to identify the relevant list of papers to be referenced in their studies by forming text clusters. Clustering is one of widely used applications of text mining. A cluster contains, if not complete, a sufficient list of papers related to the cluster definition.

We analyze the research published so far in the new emerging research areas using bibliometric analysis and text mining. First, we compare the pace of all neuroSS fields using bibliometric analysis. Secondly, we analyze the content of research in these areas using text mining. Five text clusters are formed that identify different patterns in the content published over time.

The two types of data used in this study were structured and unstructured data. The structured data collected were the bibliometric indicators and the unstructured data were the abstracts of the articles. The bibliometric data was collected from the four available databases on Web of Science (WoS): Web of Science Core Collection, CABI: CAB Abstracts, FSTA – the food science resource and MEDLINE. To extract the data from various social science databases, we used a 'keyword' search method. Five keywords were used, one for each field, to collect data from five different areas: neuroeconomics, neuromarketing, neurofinance, neuropolitics and neuroIS. The search was restricted to the year 2000 - January 2014. The results of keyword searches were filtered with "articles" as the document type, which means that only journal articles made our sample data. We did not include papers published in conference proceedings because of the typically large variability in quality of publications in conference proceedings. Because the same articles can result from the two different keywords, the dataset was cleaned to remove duplicates and assigned to the relevant field. The dataset consisted of 500 papers: 421 neuroeconomics, 51 neuromarketing, 12 neuroIS, 12 neuropolitics and only 4 neurofinance papers. After cleaning the data, the bibliometric indicators retained in the dataset corresponding to each article were title, year of publication, number of citations each year (2000- Jan 2014), total citations, average citations per year and name of the publishing journal. Only some of these measures were used for analyses. The other type of information collected was unstructured in the form of abstracts. Only abstracts of the articles were used for the text mining, as we assume that abstracts contain the objective of the paper.

Text mining was completed through the following steps:

❖ All the abstracts collected were used as input in text mining irrespective of the field. Each abstract was considered as one document. So, the input to the text mining was a collection of 500 documents.

❖ The second step was to parse the text to observe the unique terms in the documents. In addition, parts of speech, entities, synonyms and punctuation were also identified. The unique terms identified during parsing were used to create a term-by-document matrix. Each identified term in the text parsing was given a weight based on the frequency of occurrences of the same word. We used maximum entropy as a text classification method to identify the important terms. The maximum entropy estimates the conditional distribution of the class label given a document.

❖ In the third step, filtering of the text was done so that only relevant words were used for forming clusters. To filter the text, a stop list was used that contained all the common English words and did not add value to the analysis. For example, stop list contained common words like "the", "of", "have" etc., plural terms and synonyms. All the words in the stop list were ignored for further analysis.

❖ Finally, the data cleaned in the previous steps was analyzed for clustering. To form clusters, the terms classified were used in expectation-maximization method. In this method, the terms within the same cluster are more expected to occur in the same documents, as compared to the terms in other clusters.

The descriptive analyses were done to understand the progress of each subfield over time. This can be seen as the number of papers published in the respective field over time. The results of analysis are presented in Figure 1. It shows that among all the areas, economics researchers were the first to explore neuroscience literature and used it in their research in 2003. The number of papers on neuroeconomics increased over the years until 2008. From 2009-2013, the growth in the research is stagnant. After economics, marketing researchers started developing neuroscience literature in 2005, but the total output has been relatively small. Until now, the neuromarketing researchers have published less than 100 papers. The finance scholars started in 2008 but do not yet have the numbers in double digits. Although researchers first used the term neuropolitics in the late 1980s and early 1990s, it has not emerged as a significant area of research for political research. Compared to all the fields, IS researchers appear to be the last to have used neuroscience theories in their research. The first major neuroIS research was published in 2010 and until now, very few papers have been published, not even twenty according to the web of science database. Comparing all, only neuroeconomics has been able to emerge as a subfield within economics and all others are still struggling to get value from the neuroscience. We also observed the major journals in each field having published neuro papers. It was discovered that most of the journals publishing neuroeconomics paper are pure neuroscience journals rather than the classical economics journals, such as *Frontiers in neuroscience, Journal of Neuroscience, Medical Hypotheses and Frontiers in Behavioral Neuroscience*. This shows the interdisciplinary nature of this field. Although some of the papers in other areas are also published in neuroscience journals, their count of publications are not yet large enough to be ranked as a major outlet for neuroSS research.

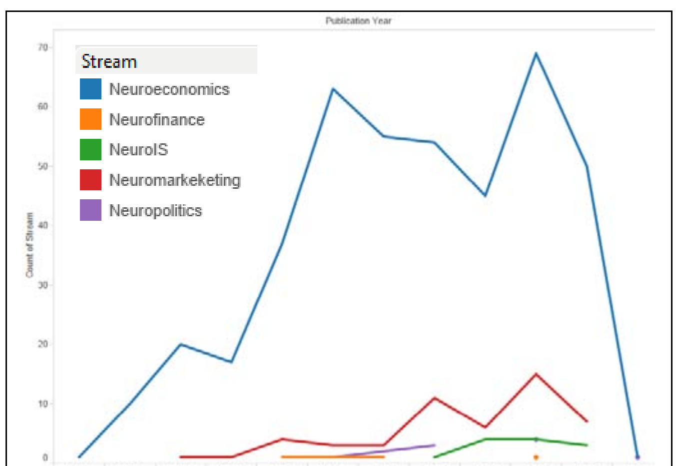


Figure 1. Number of articles published in neuroSS (2003-Jan 2014)

Using expectation maximization algorithm, five text clusters were created. Table 1 shows the top descriptive terms for each cluster and document frequency. Highly populated cluster with ID 1 comprised of 34% of the data under analysis. This cluster addresses the various social cognitive neuroscience theories applied to understand the human behaviour. Cluster 2 constitutes 22% of the total data. This cluster contains documents discussing the economics concepts such as risk-reward value, making choices or decisions and highly applied game theory. Next, cluster 3 consists of marketing research that shared 18% of the data. It contains articles that used fMRI as a primary brain-imaging tool to understand consumer behaviour. Cluster 4 is a group of 69 (14%) papers concerned about the other highly studied constructs of economics such as delayed discounting, hyperbolic discounting and impulsivity. And finally, cluster 5 was the smallest cluster with 12% of the data. It contains articles discussing about the prefrontal cortex region of the human brain that is highly used in decision-making and other social behaviours.

This is an exploratory study where we attempted to determine the trends of social neuroscience research till January 2014. The bibliometirc analysis shows that except neuroeconomics, all other streams are yet to fully develop into a sub-field within their respective disciplines. One potential reason for the growth of neuroeconomics is the alliance of the neuroscience and economics researchers. Publications of economics concepts in the neuroscience journals indicate that the constructs of economics have not only been the interest of economic researchers but also of interests to neuroscientists. This could not be possible unless researchers from both the fields share and apply common knowledge to advance their respective fields. So, this can be a lesson to all the other emerging fields to approach neuroscience experts and work together. Due to lack of training and domain expertise, it is difficult for the social science researchers to engage in neuroSS

Table 1. Text clusters

Cluster No.	Descriptive terms	Frequency (%)
1.	social, cognitive, neuroscience, theory, neuroeconomics, understanding, human	170, 34%
2.	risk, rewards, value, choice, game, subjects	108, 22%
3.	consumer, marketing, neuromarketing, frmi, imaging	92, 18%
4.	delay, discounting, hyperbolic, impulsivity, intertemporal, function	69, 14%
5.	prefrontal, cortex, associated, learning, ultimatum, offers	61, 12%

research. Experts in neuroimaging methods can help enhance the quality of research by increasing its validity. Specific conferences and workshops targeted at introducing neuroSS research methods to social science researchers have certainly increased the awareness of social science researchers, but direct collaboration between the two sides is the key to building a larger corpus of knowledge in neuroSS areas. Journals dedicated to neuroSS like *Journal of Neuroscience, Psychology, and Economics* are encouraging Neuroscience, Psychology, and Economics researchers to work together. There is no journal in IS, marketing and other fields that is similarly dedicated to the neuroscience. Although, Gmunden retreat is an annual event that tries to bring together researchers working in neuroIS, more such events and outlets will enable growth of the field. Similar strategies are highly required by the emerging neuroSS fields to encourage researchers.

The clusters formed by text mining divided the data into five different groups based on the occurrences of common terms. This grouping can help researchers in finding a sufficient list of documents related to the topic of interest. For example, if a researcher wants all the relevant neuroscience research done on risk-reward value, one can find an adequate amount of related papers from cluster 2.

There are some limitations of this study. The data used might be just a subset of the neuroSS literature. The data only consisted of journal articles but in fact, the conference proceedings also contain relevant and most recent literature. Also, we tried to include all the relevant articles from the WoS database but many journals are not registered in this database. Notwithstanding all the limitations, this exploratory study provides some useful insights to the research community interested in neuroSS. We learned that several of the social neuroscience fields are not growing as fast as neuroeconomics has grown. So, there is a concern of considering different strategies to enhance this field of research. We found that fewer constructs have been studied so far using neuroimaging methods. There is a lot of scope in this area of research as many social science concepts are yet to be studied using neuroimaging methods.

REFERENCES

- Ananiadou, S., Pyysalo, S., Tsujii, J. I., & Kell, D. B. (2010). Event extraction for systems biology by text mining the literature. Trends in biotechnology, 28(7), 381-390.
- Delen, D., & Crossland, M. D. (2008). Seeding the survey and analysis of research literature with text mining. Expert Systems with Applications, 34(3), 1707-1720.
- Diodato, V. P. (1994). Dictionary of bibliometrics. Psychology Press.
- Ochsner, K. N., & Lieberman, M. D. (2001). The emergence of social cognitive neuroscience. American Psychologist, 56(9), 717.
- Verbeek, A., Debackere, K., Luwel, M., & Zimmermann, E. (2002). Measuring progress and evolution in science and technology–I: The multiple uses of bibliometric indicators. International Journal of Management Reviews, 4(2), 179-211.

Clashing Trends: Probing the Role of Age in Technostress

Stefan Tams, HEC Montréal

Corresponding author: Stefan.tams@hec.ca

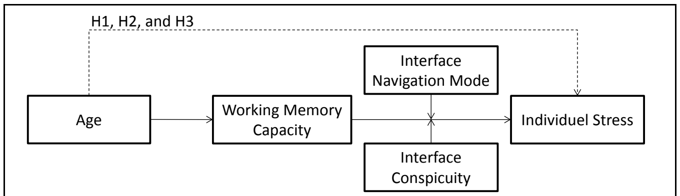
As the workforce is becoming older at a rapid rate, a phenomenon known as the greying of the workforce, new challenges arise for firms across the globe as they have to juggle this dramatic demographical change in conjunction with the proliferation of increasingly modern information and communication technologies (ICT) (Pak et al., 2009). Yet, the interdependencies inherent in these two clashing workplace trends have remained largely unexplored, although we know that age is a salient dimension of human interactions with ICT. In particular, research needs to examine the role of age in technostress (Riedl, 2013; Tarafdar et al., 2007), an emerging problem of strong practical significance.

Grounded in research on gerontology (Czaja et al., 2006) and person-environment fit (French et al., 1982), this study argues that age positively impacts ICT-induced stress due to differences in working memory capacity (WMC; i.e., peoples' capacity to process the information necessary to complete an active task) between younger and older adults. Specifically, given that peoples' WMC declines with age (Czaja et al., 2006) and given that WMC is critical for computer-based tasks as they are cognitively demanding (Birdi and Zapf, 1997), we expect older people to experience more ICT-induced stress than younger ones, i.e., we expect age to impact stress via WMC. Further, since WMC may play a greater role for hierarchy-based, disorderly interfaces than for tag-based, orderly ones (Pak & McLoughlin, 2010), we theorize that this indirect effect of age on stress via WMC depends on the mode of interface navigation (i.e., tag-based vs. hierarchy-based) and on interface conspicuity (i.e., the extent to which relevant information is shown distinctly). Thus (please also see Figure 1 and Table 1):

H1: WMC will mediate the positive effect of age on ICT-induced stress.

H2: Interface navigation mode will moderate the indirect effect of age on ICT-induced stress (via WMC) such that this indirect effect will be weaker for a tag-based than a hierarchy-based interface.

H3: Interface conspicuity will moderate the indirect effect of age on ICT-induced stress (via WMC) such that this indirect effect will be weaker for more conspicuous interfaces (i.e., more orderly interfaces).



The dotted line represents our **mediation hypotheses**, suggesting 2nd stage moderated mediation of age-related impacts by working memory capacity for H2 and H3 with interface navigation mode and conspicuity as second stage moderators.

Figure 1. Research Model

Table 1. Construct Definitions

Construct	*Definition*	*Reference*
Age	**Chronologically younger compared to older individuals**	Pak et al., 2009; Pak & McLoughlin, 2010
Working Memory Capacity	**Extent to which peoples' working memory can hold and process the information necessary to complete an active task**	Czaja et al., 2006; Pak et al., 2009
Interface Navigation Mode	**Tag-based vs. hierarchy-based navigation of an interface**	Pak et al., 2009; Pak & McLoughlin, 2010
Interface Conspicuity	**Extent of distinctiveness of relevant information in terms of disorder, distractions, and emphasis of important functions**	Pak & McLoughlin, 2010
Stress	**Extent of stress experienced by people as a result of ICT use**	Riedl, 2013

We will test the model using a lab experiment that will integrate the selection of younger and older adults with the manipulation of ICT characteristics, eye tracking, objective measures of WMC, and a biological measure of stress. As regards the latter, the study will employ the *salivary stress enzyme α-amylase* (sAA), which is a marker of the sympathetic nervous system component of the psychobiology of stress that reflects changes in the *stress hormone adrenalin* (Granger et al., 2007). sAA is classified as family 13 of the glycosyl hydrolases, and it can be collected non-invasively using oral swabs. The study will employ a 2 × 2 × 2 factorial design. We plan for 50 younger and 50 older subjects, and we will use Preacher et al.'s (2007) regression-based approach to estimate the conditional indirect effects at different levels of the moderators. In doing so, we will expound how and why age impacts technostress; that is, we will shed light on an important interdependency inherent in the two earlier-introduced, clashing workplace trends.

References

- Birdi, K. S. and Zapf, D. (1997) Age differences in reactions to errors in computer-based work, *Behaviour & IT*, 16, 6, 309-319.
- Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., et al. (2006) Factors predicting the use of technology: Findings from the center for research and education on aging and technology enhancement (create), *Psychology and Aging*, 21, 2, 333-352.
- French, J. R. P., Caplan, R. D., and Van Harrison, R. (1982). *The mechanisms of job stress and strain*. Chichester, England: J. Wiley.
- Granger, D. A., Kivlighan, K. T., el-Sheikh, M., Gordis, E. B., & Stroud, L. R. (2007). Salivary alpha-amylase in biobehavioral research. *Annals of the New York Academy of Sciences*, 1098, 122-144.
- Pak, R., and McLoughlin, A. (2010) *Designing Displays for Older Adults*, Taylor & Francis: USA.
- Pak, R., Price, M. M. and Thatcher, J. (2009) Age-sensitive design of online health information: Comparative usability study, *Journal of Medical Internet Research*, 11, 4, 6-6.
- Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007) Assessing moderated mediation hypotheses: Theory, methods, and prescriptions, *Multivariate Behavioral Research*, 42, 185–227.
- Riedl, R. (2013). On the biology of technostress: Literature review and research agenda. *ACM SIGMIS Database*, 44(1), 18-55.
- Tarafdar, M., Qiang, T. U., Ragu-Nathan, B., & Ragu-Nathan, T. (2007). The impact of technostress on role stress and productivity. *Journal of Management Information Systems*, 24(1), 301-328.

Posters

Gmunden Retreat on NeuroIS 2014

Using Eye Tracking Glasses to Analyze Mobile Device Interactions

Werner Wetzlinger, Andreas Auinger, Harald Kindermann

Corresponding author: werner.wetzlinger@fh-steyr.at

Eye tracking is a well-established method to analyze how people interact with devices. To capture eye movements most systems take a video-based approach using head mounted or remote cameras (Duchowski 2009).

Interactions with screen based devices (PCs, laptops) are usually evaluated using remote eye trackers that are attached to a static screen. In addition some require the head to be stable and use a chin rest to ensure this is the case. Consequently users look at the screen from a relatively stable distance and angle and the eye tracking software on the device can map user gazes to the content on the screen.

A second possibility to capture fixations is to use eye tracking glasses. It is a less intrusive way of recording real-world visual behavior. Increased mobility enables users to interact more naturally with the surrounding environment. This corresponds more to the natural way of using mobile devices like tablets and smartphones. Eye tracking glasses are therefore a useful technology to evaluate their use (Bulling and Gellersen 2010).

We use the binocular mobile eye tracking glasses from SensoMotoric Instruments (SMI). Its software provides a number of visualizations and analyses that allow for a research setting that combines qualitative and quantitative evaluations (Cheng 2011).

Qualitative analyses can be done by using the gaze replay function or by analyzing fixations and saccades using the scan path function. This provides insights into sequence with which users are looking at screen elements, how they navigate through multiple screens and when they look away from the device to gather further information for completing a task.

Furthermore, it is possible to define areas of interest (AOIs) using layered geometrical shapes to calculate typical statistical indicators (Pool and Ball 2005) like sequence, entry time, dwell time, hit ratio, revisits, revisitors, average fixation, first fixation, fixation count, glance duration and appearance count. Since the gaze angle of a user's eye changes over time, the positions of these AOIs need be adapted accordingly. Based on these quantitative KPIs we can evaluate a number of usage aspects like the attention to certain items (dwell time), whether users understand the interface items (fixation duration) or whether items are hard to find (fixation count).

If interactions of two or more participants are to be compared, a mapping of their gazes on a common reference view is necessary. This is done by mapping fixations in videos to their corresponding position on a static picture. Based on these mappings the software can compare gazes of multiple users and calculate attention visualizations like focus maps, heat maps and bee swarms. If AOIs are defined on reference views, compound statistics can be calculated. Since gazes of multiple participants have to be mapped manually to a common reverence view and the positions of AOIs have to be adjusted, these analyses are a very time-consuming task, especially if users move their head constantly and positions of the investigated device change frequently. It is therefore more efficient to create these compound quantitative measures just for screens that have been identified as crucial in a qualitative evaluation.

Furthermore we plan to combine the results of these analyses with interaction and context data. Besides visual aspects especially when using mobile devices further usability issues emerge through touch interaction problems or the context of use. Users tend to interact with the device without examining all objects on the screen, without even looking at it or while performing other activities (e.g. walking). Currently, gaze data, interaction data and context data are analyzed separately. Thus we are developing a plugin for mobile apps (Android) that tracks user interactions (touch position, used gestures etc.) and the context of use (current location, current activity, position of the device etc.). Combining this data with eye gaze data should help us identify further usability problems.

To discuss our approach, the methodology and further possible areas of application we want to demonstrate how we track and analyze mobile device interaction data using the eye tracking glasses.

References

- Bulling, A., and Gellersen, H. 2010. "Toward Mobile Eye-Based Human-Computer Interaction," *IEEE Pervasive Computing*, (9:4), pp. 8-12.
- Cheng S. 2011 "The research framework of eye-tracking based mobile device usability evaluation," *Proceedings of the 1st international workshop on pervasive eye tracking & mobile eye-based interaction*, pp. 21-26.
- Duchowski, A. 2009 Eye Tracking Methodology: Theory and Practice London, UK: Springer Verlag, pp. 51-156.
- Poole, A., Ball, L.J. 2005 "Eye Tracking in Human-Computer Interaction and Usability Research: Current Status and Future" in *Encyclopedia of Human-Computer Interaction*, Ghaoui, C. (ed.), Pennsylvania: Idea Group, pp. 211-219.

Cognitive Analysis Grid for IS Research

Laurence Dumont[1,2], Émilie Chamard[2], Pierre-Majorique Léger[1], Ana Ortiz de Guinea[1], Sylvain Sénécal[1]
1 Tech3Lab - HEC Montréal, 2. Psychology Department – Université de Montréal
Corresponding author: laurence.dumont.1@umontreal.ca

The goal of this methodological paper is to build a cognitive analysis (CA) grid to allow the identification of the different cognitive functions involved during an interaction with an information system (IS). After further validation, the CA grid could be applied to any IT task, which could help identify the cognitive processes relevant to that said task and would ultimately allow IS researchers to guide the identification of networks of interest in the brain that are relevant to their theorizing.

I. Conceptualization of the CA grid

The proposed CA grid assess the four steps involved in human cognition, namely reception of stimuli, memory, thinking and expression of response (Lezak, M.D., 2004, 2013). These four steps allow for a clear division between the different human cognitive processes associated with the performance of a task.

- Reception: Both the modality (i.e. visual, auditive, etc.) of stimulus reception and its content (visuo-spatial VS verbal-phonological) will be assessed. This will allow for a) a thorough division of what is processed by the human cognitive system as well as b) the means and neuroanatomical networks of stimulus reception.
- Memory: Three different divisions will be made in terms of memory assessment. Short term memory and long term memory will first of all be differentiated. Explicit and implicit memory will also be differentiated. Explicit memory comprises episodic and declarative memory, while implicit memory is constituted of procedural memory and priming effects.
- Thinking: Given the fact that it would be impossible to evaluate an extensive list of the mental abilities and executive functions used in the neuropsychological literature, a reduction to the twelve major executive functions groups found by Packwood et al. (2011) has been chosen to assess the cognitive manipulations of the information. These functions are: workload, creativity, theory of mind, visual search, time sharing, intentionality, generation of strategy, proneness to interference, discovering changes in rules, affective decision making, verification of hypothesis and initiation.
- Response: The expression of the response also has to be taken into consideration in the cognitive grid. The modality of the human response (motor, verbal, etc.) and the content of this response will be assessed, in the same fashion as in the reception phase.

II. Preliminary Application of the CA Grid

Data from 80 subjects interacting with a music website were used for a preliminary evaluation of the CA Grid (Sénécal et al. 2012). After the experiment, subjects were asked to elicit in writing all the steps involved in purchasing. These steps were then coded by two IT experts in order to have a thorough portrait of the possible behaviors of the subjects during the task. The complete list of steps are then divided in different subtasks (which will subsequently be called task “items”). These items have to be sufficiently partitioned to minimize the risk of overlapping between cognitive functions, but not fragmented to the point where an item is unrepresentative of a concrete part of the whole. The rule of thumb should be that an item has to apply only once in the four categories of processes stated above.

Two coders, who are experts in neuropsychology, performed the subsequent attribution of the cognitive functions comprised in the CA grid for each item of the task. Litigious situations during this process were addressed with the help of an IT expert in order to bring a different point of view. This expert later reviewed the classification of the experts in neuropsychology at the end of the process in order to finalize the classification.

III. Potential contribution of the CA Grid

The completed grid can later be used to guide both behavioral and neurological research questions. Knowing precisely the cognitive composition of a task will also allow NeuroIS researchers to draw more specific neurological hypotheses and benefit from the large body of literature in cognitive neuroscience that has already assessed both the neuroanatomical substrates and the electrophysiology of those cognitive functions. Drawing together subtasks requiring the same type of functions at different steps of the cognitive process will allow to draw precise conclusions on particular cognitive functions used during IS interactions.

References

- Lezak, M.D. (2004) Neuropsychological assessment. Fourth edition. Oxford Press
- Sénécal, S.; Léger, P-M.; Fredette, M.; Riedl, R. (2012), “Consumers' Online Cognitive Scripts: A Neurophysiological Approach,” International Conference on Information Systems, December, Orlando, Florida.
- Packwood, S., Hodgetts, H.M. & Tremblay, S. (2011) A multiperspective approach to the conceptualization of executive functions, Journal of Clinical and Experimental Neuropsychology, 33:4, 456-470, DOI: 10.1080/13803395.2010.533157

Detecting Deception in Online Environments: Measuring Fraud Through Mouse Cursor Movements

Martin Hibbeln, Braunschweig Institute of Technology, Christoph Schneider, City University of Hong Kong, Markus Weinmann, University of Liechtenstein

Corresponding author: markus.weinmann@uni.li

The rise of the Internet has given rise to a variety of ways for individuals to engage in unethical or outright fraudulent activities. Such activities can range from omission or misrepresentations in online forums to inputting false or fraudulent information in online forms, such as when applying for benefits, filling out job applications, or filing insurance claims. Such behaviors can have a sizable financial impact on organizations and society as a whole. Whereas the Internet offers much perceived anonymity, organizations have the possibility to observe various behaviors of their online users, for example by monitoring the ways in which users fill out online forms. The aim of this research-in-progress is to develop a prototype that uses easily observable mouse movement data as an indicator of potential fraud in online form submissions. To this end, we bring together research from human-computer interaction, psychology, and neuroscience, so as to hypothesize about and test ways in which fraudulent behavior can be detected by monitoring users' observable behavior in online environments.

It has been argued that lying is more cognitively demanding than telling the truth (Vrij et al., 2006). Specifically, a liar faces a number of cognitively challenging tasks, including planning what is said and avoiding contradictions, all while monitoring the reactions of the listener (Sporer and Schwandt, 2006). Whereas people telling the truth are able to *retrieve* (or reconstruct) events from memory, liars will have to *construct* plausible events (Walczyk et al., 2013). All of these tasks put a load on people's working memory (Baddeley, 2000), competing for the resources available. As a result of this cognitive load, people may not be able to effectively suppress the leaking of cues (Burgoon & Buller, 2008), and the higher cognitive load may also manifest in the way bodily movements are performed. For example, Duran et al. (2010) have shown that when asked to point with a Nintendo Wii remote control to either a truthful statement or a lie, lies manifested in slower and more disorderly hand and arm movements.

Given these findings, it stands to reason that this increased cognitive load is also likely to manifest in observable differences in mouse cursor movements. We conducted an experiment to test the possibility of detecting fraudulent behavior in online contexts. Specifically, following design science guidelines in Neuroscience (vom Brocke et al., 2013), we developed a mockup of an online insurance claim form, and implemented a mouse cursor tracking systems to record the x/y-position of the users' mouse cursor at each millisecond. This enabled us to compute several mouse cursor related variables such as cursor distance and cursor speed, as well as deviations from the direct path toward the target or movement corrections. Preliminary results of a pilot study (n= 54) indicate that various movement parameters differ between known truthful and fraudulent responses (see Table 1). As a next step, we will create characteristic movement profiles, which we will further validate using psychophysiological measures (such as Galvanic Skin Response and eye-tracking).

Table 1. T-Test of Pilot Study (Extract)

	No Fraud	Fraud	t	p
Speed (px/ms)	0.13	0.12	1.78	0.077
Distance (px)	1322.08	1584.14	-2.09	0.038

We believe that this study has important implications. Specifically, from a NeuroIS perspective, the results will provide us with further insights about potential correlates of fraudulent behavior in online contexts, and about ways to detect such behaviors in real time.

References

- Baddeley, A.D. 2000. The episodic buffer: a new component of working memory?," *Trends in Cognitive Sciences* (4:11), pp. 417-423.
- Burgoon, J.K, and Buller, D.B. 2008. "Interpersonal deception theory," in *Engaging Theories in Interpersonal Communication: Multiple Perspectives*, L.A. Baxter, and D.O. Braithewaite (eds.), Thousand Oaks, CA: SAGE, pp. 227-239.
- Duran, N.D., Dale, R., and McNamara, D.S. 2010. "The action dynamics of overcoming the truth," *Psychonomic Bulletin & Review* (17:4), pp. 486-491.
- Sporer, S.L., and Schwandt, B. 2006. "Paraverbal indicators of deception: a meta-analytical synthesis," Applied Cognitive Psychology (20:4), pp. 421-446.
- 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.
- Vrij, A., Fisher, R., Mann, S., and Leal, S. 2006. "Detecting deception by manipulating cognitive load," *Trends in Cognitive Sciences* (10:4), pp. 141-142.
- Walczyk, J.J., Igou, F.P., Dixon, A.P., and Tcholakian, T. 2013. "Advancing lie detection by inducing cognitive load on liars: a review of relevant theories and techniques guided by lessons from polygraph-based approaches," *Frontiers in Psychology* (4:14), Article 14.

Stress-Sensitive Adaptive Enterprise Systems: Theoretical Foundations and Design Blueprint

Marc T.P. Adam, Karlsruhe Institute of Technology
Henner Gimpel, Augsburg University and Fraunhofer FIT
Alexander Maedche, University of Mannheim
René Riedl, University of Applied Sciences Upper Austria and University of Linz

Corresponding author: marc.adam@kit.edu

INTRODUCTION

Stress-Sensitive Adaptive Enterprise Systems (SSAES) are neuroadaptive enterprise systems that continuously assess the users' current stress levels and autonomously adapt specific elements of the system accordingly. The aim of SSAES is to influence users' stress levels in order to improve their well-being and health, performance and productivity, and additionally create positive effects on user experience. This paper presents, based on theoretical foundations, a design blueprint for SSAES.

Stress is a major obstacle impairing well-being, health, performance, and productivity of many people. In particular, people may experience considerable levels of technostress during human-computer interaction, i.e., "negative impact on attitudes, thoughts, behaviors, or body physiology that is caused either directly or indirectly by technology" (Weil and Rosen 1997, p. 5). In this context, Riedl (2013) argues that one of the major challenges for IS design science research in the area of technostress is the development of systems that integrate biosignals as real-time stress-measures. Here, we present a design blueprint of such a system.

Enterprise Systems (ES) have dramatically and irreversibly changed the workplace of many employees worldwide. In their aim to achieve large-scale integration of data and processes across the different functional areas of an organization, ES exhibit a multitude of both technological and social facets that have a significant impact on their success (Devadoss and Pan 2007). In this sense, ES are socio-technical systems that involve a technological, an organizational, and an individual dimension, which need to be equally accounted for. ES are commonly designed to improve performance and productivity of enterprises – for many employees they are an integral part of their IT workplace. However, evidence (e.g., Ragu-Nathan et al. 2008) shows that use of large-scale information systems in organizations may lead to considerable stress in the workplace. Yet, ES appear to offer substantial potential for assessing rich context information and adapting the system.

METHODS AND CONTRIBUTION

This paper uses a descriptive and exploratory design science approach building on two pillars: A review of relevant academic literature and explorative interviews with practitioners and researchers from information systems, computer science, electrical engineering, and psychology. On these backgrounds, we envision SSAES and propose a design blueprint of such systems.

SSAES leverage neuroscience theories to inform the building of IT artifacts (vom Brocke et al. 2013; strategy 1) and neuroscience tools as built-in functions of IT artifacts (ibid; strategy 3). The design blueprint is a meta-description of purpose and scope as well as principles of form and function (Gregor and Jones 2007). It constitutes a step towards a nascent design theory and adds to prescriptive knowledge on NeuroIS (Gregor and Hevner 2013; level 2 contribution).

SSAES DESIGN

Kernel theory. Stress is activated by a set of acute or chronic stressors that trigger changes in perception and manifests in a variety of neurophysiological changes in the body which usually set on before conscious stress perception (Hancock and Warm 1989; Lazarus 1991). Neurophysiological changes include, among others, the release of the stress hormone cortisol (Riedl et al. 2012), and changes in skin conductance (Riedl et al. 2013). The elicitation of stress is subject to a user's appraisal of the situation. In this vein, a user can apply, for instance, information avoidance, stress management and other stress coping strategies to mitigate the elicitation of stress and its consequences (e.g., Denson, et al. 2009). The impact of stressors thus heavily depends on the users' individual capabilities and stress coping strategies. In order to optimize performance, a midrange level of arousal is optimal (Hancock and Szalma 2007). Excessive stress has negative impact on well-being and health, user experience, as well as performance and productivity (Tarafdar et al. 2007; Tarafdar et al. 2010); see Riedl (2013) for a review of the biology of technostress.

Information systems background. ES are traditionally seen as a specific category of information systems. They are socio-technical systems accounting for the organization, the technology, and the individuals involved.
Information systems with neuroscience tools as built-in functions need to consider these three perspectives: the organization, technology, and individual (e.g., Gimpel et al. 2013). From a technological point of view, ES offer a set of functional modules, generally based on industry best practices implemented in packaged software (Markus and Tanis 2000). The term ES has grown to refer to all large organization-wide packaged software applications (Seddon et al. 2010), including people-centric software (e.g. Groupware), process-centric software (e.g. Enterprise Resource Planning, Customer Relationship Management), and information-centric software (e.g. Data Warehouses, Business Intelligence). On the organizational side, ES relate to business processes as well as roles and responsibilities; they are embedded in an organizational context.

Design requirements and challenges. The overarching objective of SSAES is to achieve humanistic goals (well-being, health, satisfaction, user experience) and instrumental goals (performance, productivity, cost-effectiveness of stress-sensitive adaptation). This requires appropriate sensors and effectors at the individual, technological, and organizational level of ES. The operationalization of the goals is scenario specific. The term *appropriate* refers to (i) technical feasibility, (ii) social and ethical acceptability, and (iii) individual technology acceptance.

Technical feasibility includes hardware and signal processing for long-term, unobtrusive, continuous, and reliable physiological and behavioral stress assessment and analytics. Second, technical feasibility of the adaptation of ES packaged software requires incorporating real-time feedback. Social and ethical acceptability of SSAES is critical: Exploring data privacy issues and the implications of SSAES for future work environments and users is an open research challenge. At the level of individual technology acceptance, general determinants of technology adoption and use are well known in IS research – the challenge is to design SSAES that account for these determinants and to study their relevance for SSAES. Furthermore, post-adoption IS research specifically investigating use behavior from a dynamic, process perspective and effectiveness and efficacy with respect to the humanistic and instrumental goals need to be considered when designing SSAES.

Sensors and effectors. SSAES assess their users' stress level via sensors (1) assessing physiological correlates of stress (activation of the sympathetic and parasympathetic divisions of the autonomic nervous system), (2) observing user behavior, and (3) eliciting subjective stress perceptions. These data might be paired with context information, e.g. on physical activity, location, informations systems and functionalities used, and business processes. The sensor data enters user models within the SSAES. If deemed beneficial and desired by the user, stress-specific interventions adapt the SSAES: individual user awareness, adaptive user interface, and adaptive packaged software at the backend.

Iterative design. SSAES have individual, technological, and organizational components, like any ES. The design of SSAES is necessarily a partial and incremental process (Peffers et al. 2007). The design requirements and challenges associated with SSAES should be explored and resolved consecutively. Hence, we propose to structure the design and introduction of SSAES along maturity levels. A first maturity level may include, for example, only individual local feedback and interface adaptations. Such a restricted scope limits the potential stress-specific interventions and effects. However, it eases technical implementation and limits data privacy issues. Further maturity levels can, for example, open up communication to the backend packed software to allow for analytics and adaptations in the backend. The potential for additional interventions comes at the cost of higher technological complexity and might go along with, for example, decreased user acceptance.

Complementing the rather technology-oriented maturity levels, we suggest research on how to facilitate adaptive organizational structures based on aggregate feedback on stressors. An adaptive organization could re-design business processes to eliminate stressors; roles and responsibilities could be re-allocated to reduce users' stress levels. These visions come along with a multitude of social, ethical, and legal aspects which need to be explored.

Discussion and Conclusions

This paper presents theoretical foundations and a first design blueprint for stress-sensitive adaptive enterprise-systems (SSAES). In the terminology of design science research knowledge contributions (Gregor and Hevner 2013), this is an innovation, applying a new solution (stress-sensitive information systems) to a new problem (technostress in the context of enterprise systems). While we believe that our SSAES blueprint makes a useful contribution to technostress research, the following limitations should be considered. First, technostress is an individual, organizational, and societal problem caused by information and communication technologies; hence, technologically solving the problem (i.e., by a SSAES) is by no means the only way, or necessarily the most effective one. Second, the paper deals with the problem from a technical perspective, falling short in fully reflecting the organizational, societal, ethical, and legal drawbacks. Third, this conceptual work needs to be enriched by design and empirical research. Currently, we are working on a first prototypical SSAES implementation and associated laboratory studies.

REFERENCES

- Denson, T.F., Spanovic, M., and Miller, N. 2009. "Cognitive Appraisals and Emotions Predict Cortisol and Immune Responses: A Meta-Analysis of Acute Laboratory Social Stressors and Emotion Inductions," *Psychological Bulletin* (135:6), pp. 823-853.
- Devadoss, P., and Pan, S.L. 2007. "Enterprise Systems Use: Towards a Structural Analysis of Enterprise Systems Induced Organizational Transformation," *Communications of the AIS*, 19 (1), 362–385.
- Gimpel, H., Adam, M.T.P., and Teubner, T. 2013. "Emotion Regulation in Management: Harnessing the Potential of NeuroIS Tools," *Proceedings of the 2013 European Conference on Information Systems (ECIS 2013)*.
- Gregor, S., and Hevner, A.R. 2013. "Positioning and Presenting Design Science Research for Maximum Impact," *MIS Quarterly* (37:2), pp. 337-355.
- Hancock, P.A., and Szalma, J.L. 2007. "Stress and Neuroergonomics," in *Neuroergonomics: The Brain at Work*, R. Parasuraman and M. Rizzo (eds.), New York: Oxford University Press, pp. 195-206.
- Hancock, P.A., and Warm, J.S. 1989. "A Dynamic Model of Stress and Sustained Attention," *Human Factors: The Journal of the Human Factors and Ergonomics Society* (31:5), pp. 519-537.
- Gregor, S., and Jones, D. 2007. "The Anatomy of a Design Theory," *Journal of the Association of Information Systems* (8:5), pp. 312-335.
- Lazarus, R. 1991. "Psychological Stress in the Workplace," *Journal of Social Behavior & Personality* (6:7), pp. 1-13.
- Markus, M.L., and Tanis, C. 2000. "The Enterprise System Experience – From Adoption to Success," in *Framing the Domains of IT Management: Projecting the Future Through the Past*, R.W. Zmund (ed.), Cincinnati: Pinnaflex Educational Resources, pp. 173–207.
- Peffers, K., Tuunanen, T., Rothenberger, M., and Chatterjee, S. 2007. "A Design Science Research Methodology for Information Systems Research," *Journal of Management Information Systems* (24:3), pp. 45-77.
- Ragu-Nathan, T.S., Tarafdar, M., Ragu-Nathan, B. S., and Tu, Q. 2008. "The Consequences of Technostress for End Users in Organizations: Conceptual Development and Empirical Validation," *Information Systems Research* (19:4), pp. 417-433.
- Riedl, R. 2013. "On the Biology of Technostress: Literature Review and Research Agenda," *The DATA BASE for Advances in Information Systems* (44:1), pp. 18-55.
- Riedl, R., Kindermann, H., Auinger, A., and Javor, A. 2012. "Technostress From a Neurobiological Perspective: System Breakdown Increases the Stress Hormone Cortisol in Computer Users," *Business & Information Systems Engineering* (4:2), pp. 61-69.
- Riedl, R., Kindermann, H., Auinger, A., and 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.
- Seddon, B.P.B., and Calvert, C. 2010. "A Multi-Project Model of Key Factors Affecting Organizational Benefits from Enterprise Systems," *MIS Quarterly* (34:2) pp. 305-328.
- Tarafdar, M., Tu, Q., Ragu-Nathan, B.S., and Ragu-Nathan, T.S. 2007. "The Impact of Technostress on Role Stress and Productivity," *Journal of Management Information Systems* (24:1), pp. 301-318.
- Tarafdar, M., Tu, Q., and Ragu-Nathan, T.S. 2010. "Impact of Technostress on End-User Satisfaction and Performance," *Journal of Management Information Systems* (27:3), pp. 303–334.
- vom Brocke, J., Riedl, R., and Léger, P.-M. 2013. "Application Strategies for Neuroscience in Information Systems Design Science Research," *Journal of Computer Information Systems* (53:3), pp. 1–13.
- Weil, M.M. and Rosen, L.D. 1998. *TechnoStress: Coping With Technology @WORK @HOME @PLAY*, New York: John Wiley & Sons.

How the Need for Status Influences Neural Activation Patterns of Reward Stimuli

Jakob Perktold, Marion Brandstaetter, Thomas, Foscht, Kathrin Bauernhofer (all Karl-Franzens-University Graz)

Corresponding author: jakob.perktold@uni-graz.at

Social status is a big deal in today's society – and it always was. One reason for this can be found in the evolutionary history of mankind. Since ever social status is linked to benefits like attractive sexual partners, generous compensation or other privileges. Unsurprisingly companies are interested in offering rewards that increase a person's social status. Company cars as cultural objects are such rewards that signal wealth, social dominance and act as strong social reinforces. Recently, it has been shown that reward mechanisms are involved in the regulation of social relations like dominance and social rank. For this reason we investigated the rewarding properties of different types of cars using event-related functional magnetic resonance imaging (fMRI) and linked them to the individual need for status. Based on evolutionary considerations we hypothesized that company cars are a strong signal for social status and would activate the human reward system stronger than normal cars. Furthermore, people with a high need for status should react more strongly to company cars than people who are less status oriented.

In total 45 (30 female, 15 male) right-handed, college-aged subjects participated in this study. Stimulus material consisted of two grey-scaled car images (company/normal), two grey-scaled arrow images (up/down) and 54 slightly different comparison-tasks. The need for social status was assessed with the social consumption scale of Eastman, Goldsmith, & Finn (1999). To present the most rewarding and punishing stimulus material, participants had to choose their most and least favored car manufacturer in a prescan. All car images were presented from a semi-frontal perspective and with empty background. Both groups of cars (company/normal) were comparable in form, size and price within its group.

We employed an event-related design consisting of two blocks and each block included 54 slightly different comparison-tasks: subjects had to differentiate between two scatterplots that were shown for 400 ms followed by a 3000 ms screen prompting them to judge whether the left or right scatterplot entailed more black dots. In the first block images of cars were shown after each trial and depending on the subject's performance either the company or the normal car was chromatically enframed. The second block was the arrow-control-task and its design was nearly the same like it was in the car setting, presenting images of arrows instead of cars this time. The purpose of the second block was to subtract neural activation that arose from perceived joy due to giving the right or wrong answer. Because of adaptive testing the comparison-task was equally difficult for everyone in both blocks.

Preliminary behavioral results indicate that the presentation of cars yielded to faster response times than the arrow-setting – this seems to be especially true for people with a high need for status. Neurophysiological results suggest that highly status oriented people respond stronger to company cars than people with a low need for status do. Furthermore, company cars seem to elicit stronger activation patterns in certain reward areas (e. g. Ncl. Acc., Ncl. Caudautus) than normal cars and arrow-images. In short, preliminary results suggest that company cars are perceived as strong social rewards especially if a person's need for status is highly pronounced.

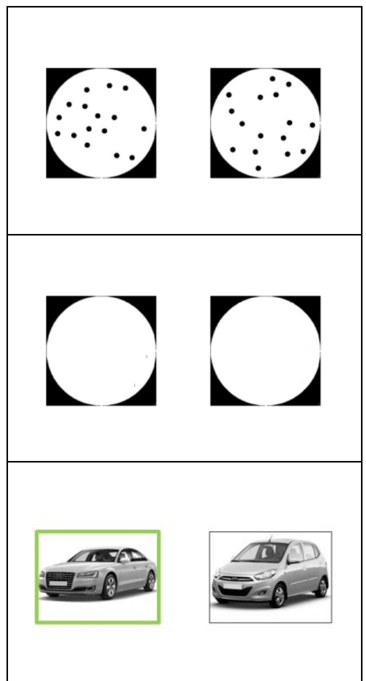


Figure 1. First block-design

References

❖ Eastman, J. E., Goldsmith, R.E., and Flynn, L.R. 1999. "Status consumption in consumer behavior: Scale development and validation," *Journal of Marketing Theory and Practice (7:3)*, pp. 41-52.

The Relationship between Psychological, Physiological, and Behavioral Strain towards Technostress

Christoph Weinert, University of Bamberg, Christian Maier, University of Bamberg, Sven Laumer, University of Bamberg

Corresponding author: christoph.weinert@uni-bamberg.de

Technological stressors cause psychological and behavioral strains (Maier et al. 2014) and lead to physiological responses (Riedl et al. 2012). Technostress research distinguishes between behavioral strains which refer to behavioral reactions such as productivity and performance and psychological strains (PSS) which are emotional reactions such as satisfaction and emotional exhaustion (Tarafdar et al. 2010). Riedl et al. (2012) also claim that individuals respond to stressors in a physiological way. Physiological strains (PHS) include among others bodily reactions such as a changed heart rate (HR) as well as changes in the skin conductance responses (SCR), and in the cortisol levels (Hellhammer and Schubert 2011).

Different types of strains have been detected as a result of being exposed to technology stressors, however their antecedents as well as their consequences differ. Stressors that influence PSS are not the same as the stressors which influence PHS (Lazarus 1993). For instance, a malfunction of the internet leads to psychological strain in terms of dissatisfaction but might not change the HR or the blood pressure. Furthermore, the relationship between PHS and PSS remains unclear. Therefore, we follow the research question how PHS influences behavioral strains and how PHS differs from PSS and vice versa.

In technostress research, the influence of PSS on behavioral strains is well established (Tarafdar et al. 2010). Hence, we assume that behavioral strain is negatively influenced by PSS, because the negative emotional reactions also have a negative effect on the behavior, for example in terms of poorer performance, (Proposition 1). In contrast to that, the relationship between PHS and behavioral strain is not well studied. According to the general adaptation syndrome (Selye 1946) stressors lead to an exhaustion of the physiological resources that weaken the bodily functions. Based on this physiological exhaustion, we assume that PHS also negatively influences the behavioral strains (Proposition 2). Furthermore, divergences between psychological and physiological strains have been acknowledged in psychological literature (Hellhammer and Schubert 2011). Several studies reveal evidence for the relationship between psychological and physiological strain, whereas, on the contrary, some investigations failed to prove a relation between PSS and PHS (Hellhammer and Schubert 2011; Hjortskov et al. 2004). The reason for this is the different on and offsets of the reaction as well as dynamic of the response. Psychological strains occur faster than physiological strains and are more dynamic (Schlotz et al. 2008). Because of the temporal delay between PSS and PHS and the different dynamic response times, we assume the existence of divergences between PSS and PHS (Proposition 3). The proposed research model is displayed in Figure 1.

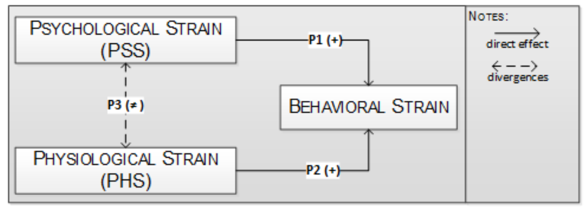


Figure 1: Relationship between psychological, physiological, and behavioral strain

To test these propositions we aim to realize a laboratory experiment, in which subjects working with an IT system are influenced by a computer freezing. The experiment follows a one factor (stressor, non stressor) between subject design and contains four tasks which have to be operated with MS SharePoint. While working on the tasks the subjects are exposed to a computer freeze. During the experiment, we attempt to measure PHS in a multivariate manner by measuring SCR, HR, blood pressure as well as eye movement in order to avoid a single item measurement and a mono-operationalized bias. PSS is measured by the psychological strain construct based on Ayyagari et al. (2011) and behavioral strain in terms of end-user performance is captured by the task results and by the processing time of each task. We expect to find differences in the extent between PSS and PHS as well as a different impact on behavioral strains. By examining the influence of PHS on behavioral strains, we attempt to contribute to technostress literature by showing that not only psychological strains but also physiological strains towards technological stressors influence the behavior of technology end-users. Furthermore, we contribute to technostress literature by investigating the divergence between PSS and PHS and its consequences.

References

- Ayyagari, R., Varun, G., and Russell, P. 2011. "Technostress: Technological Antecedents and Implications," *MIS Quarterly* (35:4), pp. 831–858.
- Hellhammer, J., and Schubert, M. 2012. "The Physiological Response to Trier Social Stress Test Relates to Subjective Measures of Stress during but not Before or After the Test," *Psychoneuroendocrinology* (37:1), pp. 119–124.
- Hjortskov, N., Garde, A. H., Ørbæk, P., and Hansen, Å. M. 2004. "Evaluation of Salivary Cortisol as a Biomarker of Self-reported Mental Stress in Field Studies," *Stress and Health* (20:2), pp. 91–98.
- Lazarus, R. S. 1993. "From Psychological Stress to the Emotions: A History of Changing Outlooks," *Annual Review of Psychology* (44:1), pp. 1–22.
- Maier, C., Laumer, S., Eckhardt, A., and Weitzel, T. 2014. "Giving Too Much Social Support: Social Overload on Social Networking Sites," *Forthcoming in: European Journal of Information Systems*.
- Riedl, R., Kindermann, H., Auinger, A., and Javor, A. 2012. "Technostress from a Neurobiological Perspective: On the Biology of Technostress: Literature Review," *Business & Information Systems Engineering* (4:2), pp. 61-69.
- Schlotz, W., Kumsta, R., Layes, I., Entringer, S., Jones, A., and Wust, S. 2008. "Covariance Between Psychological and Endocrine Responses to Pharmacological Challenge and Psychosocial Stress: A Question of Timing," *Psychosomatic Medicine* (70:7), pp. 787–796.
- Selye, H. 1946. "The General Adaptation Syndrome and the Diseases of Adaptation1," *The Journal of Clinical Endocrinology & Metabolism* (6:2), pp. 117–230.
- Tarafdar, M., Tu, Q., and Ragu-Nathan, T. S. 2010. "Impact of Technostress on End-User Satisfaction and Performance," *Journal of Management Information Systems* (27:3), pp. 303–334.

The Neural Response to Charismatic Leaders

Sabine Bergner, Robert Rybnicek, Karl Koschutnig, Alfred Gutschelhofer
(all authors from Graz University, Austria)

Corresponding author: sabine.bergner@uni-graz.at

There is a saying that 'A good boss can make your career, but a bad boss can make your life miserable'. In line with this saying behavioral research demonstrates that leaders clearly impact the motivation of their subordinates to perform well in the job (Judge & Piccolo, 2004). Recent findings suggest that particularly charismatic leadership enhances subordinates' motivation which in consequence increases their job performance (Walumbwa et al., 2008). Charismatic leaders move their followers beyond self-interests through charisma, inspiration, and intellectual stimulation. In contrast laissez-faire leadership resembles the avoidance of leadership and refers to being absent when needed or taking no action even when problems arise. Contrary to charismatic leadership laissez-faire leadership negatively relates to subordinates' job performance and motivation (Judge & Piccolo, 2004). Since motivation can be described as an individual's propensity to obtain reward, working for a charismatic leader might be regarded as a reward whereas working for a laissez-faire leader might be regarded as punishment. Based on this assumption the aim of the study was to assess whether the neural mechanisms underlying the experience of charismatic leadership and laissez-faire leadership would resemble those that can be observed when experiencing other rewarding or punishing stimuli.

An event-related functional magnetic resonance imaging (fMRI) study was conducted using a comparison task followed by leadership and monetary incentives. In total, 43 healthy students (15 male) with a mean age of 23 years participated in both steps of the study. In the pre-scan step participants were introduced to the leadership and monetary incentives. The prospects of a certain amount of Euros served as monetary incentives. The rewarding monetary incentive was a high gain of Euros (a picture of bank notes). In contrast, the punishing monetary incentive was a very small gain of Euros (a picture of coins). Leadership incentives were two leaders offering the subject a job in their team. Each leader was represented by a photo with neutral emotional expression. In the pre-scan step participants learned that one photo represented a charismatic leader (rewarding incentive) while the other one represented a laissez-faire leader (punishing social incentive). In order to combine the photos with the particular leadership style, participants listened to the recording of a speech that was given by the leaders to their subordinates. One recording contained the speech of the charismatic whereas the other contained the speech of the laissez-faire leader. In fact, the speeches were fake, written by the researchers and spoken by two actors. The content of the speeches were the same whereas the chosen wording, intonation of the speaker as well as pace, tone of voice and volume was manipulated. Thus, for the subjects the impression arose that they could have a job in the team of a charismatic versus a laissez-faire leader.

During the scan, in phase 2, participants engaged in a comparison task that was followed by leadership (pictures of a charismatic or laissez-faire leader) and monetary incentives (gaining more or less money). Participants completed one block of 54 trials on each incentive. At the comparison task participants were instructed to indicate which one of two simultaneously presented sets of dots contained the larger number of dots. The ipsative scaling of the task guaranteed a hit rate of 60% for all subjects. In the leadership reward block a hit or respectively an incorrect answer was followed by the framing of the charismatic or respectively laissez-faire leader's photo. In the monetary reward block a hit or an incorrect answer was followed by the framing of the bank notes or respectively the coins (see Fig. 1).

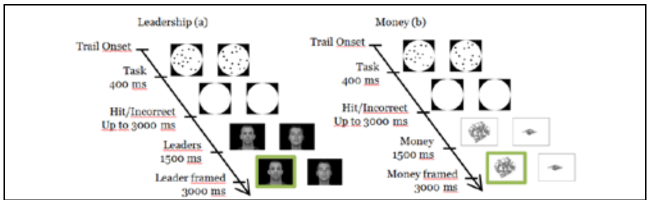


Figure 1. Task, leadership & monetary incentive

The behavioral manipulation check for the leadership incentives indicated that charismatic leaders were clearly perceived as charismatic, and much more preferred as laissez-faire leaders. In addition, reaction time varied as a function of reward sensitivity; those to whom leaders played a more important role at work than money were faster in the leadership reward block. Preliminary neuro-imaging results displayed substantial overlap between the leadership and monetary reward incentive in the nucleus accumbens, caudate nucleus, and ventromedial prefrontal cortex. Moreover, the more charismatic a leaders was rated the stronger was the activation in the aforementioned ROIs. Findings illustrate that on a neural basis a charismatic leader motivates in a similar manner as the perspective to receive more money.

References

- Judge, T.A., and Piccolo, R.F. 2004. "Transformational and transactional leadership: a meta-analytic test of their relative validity," *Journal of Applied Psychology* (89:5), pp. 755-778.
- Walumbwa, F.O., Avolio, B.J., and Zhu, W. 2008. "How transformational leadership weaves its influence on individual job performance: The role of identification and efficacy beliefs," *Personnel Psychology* (61:4), pp. 793-825.

Texting While Walking: Measuring the Impact on Pedestrian Visual Attention

François Courtemanche, HEC Montréal, Pierre-Majorique Léger, HEC Montréal, Ann-Frances Cameron, HEC Montréal, Jocelyn Faubert, University of Montréal, Élise Labonté-LeMoyne, HEC Montréal, Sylvain Sénécal, HEC Montréal, Marc Fredette, HEC Montréal, François Bellavance, HEC Montréal

Corresponding author: francois.courtemanche@hec.ca

The use of smartphones is rapidly growing around the world. In Canada, the percentage of smart phone owners has increased from nearly 20% in 2011 to 54% in early 2012 (Power and Associates, 2012). The negative impact of mobile phone use on drivers' safety has been demonstrated (Horrey and Wickens, 2006) However, the safety hazards related to mobile phones do not only apply to drivers. A large number of road accidents involving pedestrians distracted by their phones have been reported. Studies suggest that this number is growing, especially among people under 30 years old (Schwebel *et al.*, 2012). In addition, many of the fatalities which occur among pedestrians are the result of inattention (Bungum *et al.*, 2005). Most studies have addressed this problem using observational research paradigms (Starvinos *et al.*, 2011; Hyman *et al.*, 2010) but few have systematically studied the impact of mobile communication technologies on users' attention while walking. This project aims to assess the influence of using smart phones on pedestrians' visual attention and safety.

To do so, the developed methodology employs electroencephalography (EEG) and behavioral measures. Participants will be using the text messaging functionality of a smart phone while walking on a treadmill. The experiment will take place in an immersive 3D environment at the Optometry School of the University of Montréal[1]. The 3D environment includes high-resolution floor to ceiling screens in front, and to each side of the participant. Each participant's test session will be composed of several trials which include:

- Participant is engaged in a texting conversation with a research assistant while walking on the treadmill.
- Participant is prompted to look at the screen in front of him.
- A silhouette (biologically similar to a human form) is displayed walking toward the participant with a small angle deviation. The participant is asked to verbally identify the silhouette's direction (Legault *et al.*, 2012).
- Participant continues the texting discussion.

Dependent variables will include time to report on silhouette, correctness of silhouette's reported direction, EEG frequency analyses and event-related potentials.

The experiment will take place during the month of May 2014. Twenty participants will be recruited (between 20 and 34 years old). They will have owned a smart phone for at least 6 months and use it occasionally while walking. The poster will present the complete methodology and acquisition setup along with preliminary results.

References

- Canadian Wireless Total Ownership Experience Study. (2012): J.D. Power and Associates.
- Horrey, W. J., & Wickens, C. D. (2006). Examining the Impact of Cell Phone Conversations on Driving Using Meta-Analytic Techniques. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 48(1).
- Schwebel, D. C., Stavrinos, D., Byington, K. W., Davis, T., O'Neal, E. E., & de Jong, D. (2012). Distraction and pedestrian safety: How talking on the phone, texting, and listening to music impact crossing the street. *Accident Analysis & Prevention*, 45(0), 266-271.
- Bungum, T., Day, C., & Henry, L. (2005). The association of distraction and caution displayed by pedestrians at a lighted crosswalk. *Journal of Community Health*, 30(4), 269-279.
- Stavrinos, D., Byington, K. W., & Schwebel, D. C. (2011). Distracted walking: Cell phones increase injury risk for college pedestrians. *Journal of Safety Research*, 42(2), 101-107.
- Hyman, I. E., Boss, S. M., Wise, B. M., McKenzie, K. E., & Caggiano, J. M. (2010). Did you see the unicycling clown? Inattentional blindness while walking and talking on a cell phone. *Applied Cognitive Psychology*, 24(5), 597-607.
- Legault, I., Troje, N. F., & Faubert, J. (2012). Healthy older observers cannot use biological-motion point-light information efficiently within 4 m of themselves. *i-Perception*, 3(2), 104-111.

[1]http://vision.opto.umontreal.ca/english/technologies/technologies_en.html#cave

Technostress in Organizations: A Cybernetic Approach

Thomas Fischer, University of Applied Sciences Upper Austria,
René Riedl, University of Applied Sciences Upper Austria & University of Linz

rene.riedl@fh-steyr.at

Technostress is defined as "*any negative impact on attitudes, thoughts, behaviors, or body physiology that is caused either directly or indirectly by technology*" (Weil and Rosen 1997, p. 5). Due to ever increasing pervasiveness of information and communication technologies (ICT) in human society, along with a trend towards intensified use of mobile technology (e.g. Forbes 2012; Gartner 2013) technostress has become a serious problem in human society worldwide (Riedl 2013). Specifically with one third of the world population having access to the internet (Internetworldstats), and more than one billion shipments of smartphones per year (IDC 2013), it is obvious that ICT has become a significant factor in human society (Coovert et al. 2005).

The benefits of higher technological penetration are well established, ranging from increases in productivity and convenience (Wang et al. 2008) to the reduction of stress by reducing the overall workload (Wastell and Newman 1996). These benefits are potent drivers for the organizational adoption of ICT, though, as research into technostress has shown, technology can also have detrimental side-effects. Examples include effects on the physiological, emotional, cognitive, and behavioral level (Kahn 1970; Kahn and Byosiere 1990). Specifically, among others, higher risk of cardiovascular disease (Vrijkotte et al. 2000), increased mental strain (Johansson and Aronsson 1984), as well as decreases in job satisfaction and productivity (Tarafdar et al. 2010) are reported in the literature. These effects of ICT usage indicate that technology is a double-edged sword, leading to significant benefits on the one hand, but also to technostress and its detrimental effects on the other hand (e.g. employee's poor health).

Accordingly, there is a need for more technostress research on an organizational level, which in the past has often been abandoned in favor of laboratory studies that have an explicit focus on the specific aspects of technostress on the individual level of analysis (Riedl 2013). However, while laboratory experiments are necessary to establish specific cause-effect-relationships (e.g. Does computer breakdown lead to stress hormone elevations?), such studies cannot comprehensively capture the phenomenon. Rather, only very specific aspects can be studied, neglecting that technostress is a multidimensional and context-dependent phenomenon. Consequently, technostress cannot be conceptualized as a phenomenon originating exclusively in the individual or the environment, but arising from interplay of both factors.

This change of understanding in stress research has seen a long development since Selye's first publication on stress in 1936 (Selye 1936) which is also the first response-based approach to stress. *Response-based* means that stress is understood as the outcome of certain stressors in the environment disrupting the individual, and hence stress is conceptualized as the dependent variable (Edwards 1992; Cooper et al. 2001; Sonnentag and Frese 2013). In contrast, *stimulus-based* models present the opposite, defining stress as some force in the environment leading to certain reactions in the individual (Edwards 1992; Cooper et al. 2001). More modern approaches abandoned this thought of stress being located in either the individual or the environment.

The *Transactional Theory* by Lazarus (Lazarus 1966), a popular representative for this type of understanding in technostress research (e.g. Ragu-Nathan et al. 2008; Tarafdar et al. 2010; Tarafdar et al. 2011), introduced the definition of stress as "*a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being*" (Lazarus and Folkman 1984, p. 19). Thus, stress emerges through the dynamic process of resource transactions between the individual and environment which can lead to the exhaustion of an individual's capacities. Transactional Theory includes far more elaborate mechanisms; nonetheless its essential concepts are based on developments in another field of study which has seen wide, but often implicit (Edwards 1992), adoption in stress research, namely *Cybernetics*.

Cybernetics refers to the "*study of methods of feedback control*" (Miller 1965, p. 227) which, per definition, already partially introduces one of its major concepts, the negative feedback loop. Used in Lazarus' Transactional Theory and other theories of organizational stress (Edwards 1992), the negative feedback loop essentially entails the effect of information fed back to the individual leading to a process of self-regulation. This concept of feedback as an essential element in self-regulating systems experienced major influence by Norbert Wiener (1961), an early pioneer in Cybernetics.

With the negative feedback in the center of their focus, cybernetic approaches to organizational stress adopted an understanding of stress as a relationship between the individual and environment, with the individual seeking to maintain a kind of equilibrium (LeFevre et al. 2003).

In contrast to Transactional Theory though, cybernetic approaches to organizational stress more explicitly focus on the subjective occurrence of stress by involving the discrepancy between desires and perceptions (e.g. Cummings and Cooper 1979; Edwards 1992) instead of demands and resources/abilities (Lazarus and Folkman 1984). Edwards (1992) explicitly cited this difference in orientation as strength of cybernetic approaches, as an individual's desires determine whether an outside demand is perceived as important (therefore having higher impact) or not. Following these remarks, cybernetic approaches to organizational stress promise to offer some benefits from a theoretical point of view, and could thus be seen as a viable alternative to theories used so far in technostress research. Amazingly, after analyzing previous research on technostress on an organizational level (N = 17), we could not find any papers using a cybernetic approach. This finding indicates a significant gap in technostress research, because the cybernetic approach has been identified as useful in organizational stress research in general (e.g. Cummings and Cooper 1979; Edwards 1992).

Technostress is a multi-dimensional construct (Ragu-Nathan et al. 2008), involving both psychological as well as biological processes in the individual (Riedl 2013). Moreover, when using models of stress based on cybernetic principles to conduct research on technostress, subjective perceptions and especially individual's desires play a major role in the occurrence of stress (e.g. Cummings and Cooper 1979; Edwards 1992). Yet, not only individual aspects are involved in the stress development, but also aspects of the environment which are perceived by the individual. Consequently, creating a comprehensive understanding of technostress is hardly possible by one type of data set alone, but requires a mixed method approach, focusing on all major components of the individual and the environment involved. After analyzing previous research we found that such a cybernetic approach, presumably due to its high level of complexity, has rarely been used so far.

Thus, technostress would greatly benefit from the application of a cybernetic framework, based on a mixed method approach that comprises physiological, perceptual, and behavioral data sets.

References

- Ayyagari, R., Grover, V., and Purvis, R. 2011. "Technostress: Technological Antecedents and Implications," *MIS Quarterly* (35:4), pp. 831–858.
- Cooper, C. L., Dewe, P., and O'Driscoll, M. P. 2001. *Organizational stress*: *A review and critique of theory, research, and applications*, Thousand Oaks, Calif: Sage.
- Coovert, M. D., Thompson, L. F., and Craiger, P. J. 2005. "Technology" in *Handbook of work stress*, J. Barling, E. K. Kelloway, and M. R. Frone (eds.), Thousand Oaks, Calif: SAGE Publications, pp. 299–324.
- Cummings, T. G, Cooper, G. L. 1979. "A Cybernetic Framework for Studying Occupational Stress," *Human Relations* (32:5), pp. 395–418.
- Edwards, J. R. 1992. "A Cybernetic Theory of Stress, Coping and Well-Being in Organizations," *The Academy of Management Review* (17:2), pp. 238–274.
- Frese, M. 1987. "Human-Computer Interaction in the Office," in *International review of industrial and organizational psychology*, C. L. Cooper, and I. T. Robertson (eds.), Chichester: Wiley, pp. 117–165.
- Forbes 2012, http://www.forbes.com/sites/parmyolson/2012/12/04/5-eye-opening-stats-that-show-the-world-is-going-mobile.
- Gartner 2013, http://www.gartner.com/newsroom/id/2603623.
- IDC 2013, https://www.idc.com/getdoc.jsp?containerId=prUS24645514.
- Internetworldstats, http://www.internetworldstats.com.
- Kahn, R. L. 1970. "Some Propositions toward a Researchable Conceptualization of Stress," in *Social and psychological factors in stress*, J. E. McGrath, and I. Altman (eds.), New York: Holt, Rinehart and Winston, pp. 97–103.
- Kahn, R. L., and Byosiere, P. 1990. "Stress in Organizations," in *Handbook of industrial and organizational psychology*, M. D. Dunnette, and L. M. Hough (eds.), Palo Alto, Calif: Consulting Psychologists Press, pp. 571–650.
- Lazarus, R. S. 1966. *Psychological Stress and the Coping Process*, New York: McGraw Hill.
- Lazarus, R. S., and Folkman, S. 1984. *Stress, appraisal, and coping*, New York: Springer Pub. Co.
- Le Fevre, M., Matheny, J., and Kolt, G. S. 2003. "Eustress, distress, and interpretation in occupational stress," *Journal of Managerial Psychology* (18:7), pp. 726–744.
- Miller, J. G. 1965. "Living systems: Basic concepts," *Behavioral Science* (10:3), pp. 193–237.
- Ragu-Nathan, T. S., Tarafdar, M., Ragu-Nathan, B. S., and Tu, Q. 2008. "The Consequences of Technostress for End Users in Organizations: Conceptual Development and Empirical Validation," *Information Systems Research* (19:4), pp. 417–433.
- Riedl, R. 2013. "On the biology of technostress," *ACM SIGMIS Database* (44:1), pp. 18-55.
- Riedl, R., Kindermann, H., Auinger, A., and Javor, A. 2012. "Technostress from a Neurobiological Perspective - System Breakdown Increases the Stress Hormone Cortisol in Computer Users," *Business & Information Systems Engineering* (4:2), pp. 61–69.
- Riedl, R., Kindermann, H., Auinger, A., and 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* (1), pp. 1–8.
- Selye, H. 1936. "A Syndrome produced by Diverse Nocuous Agents," *Nature* (138), pp. 32-32.
- Sonnentag, S., and Frese, M. 2003. "Stress in Organizations," in *Handbook of Psychology*, I. B. Weiner (ed.), Hoboken, NJ, USA: John Wiley & Sons, Inc.
- Tarafdar, M., Tu, Q., and Ragu-Nathan, T. S. 2010. "Impact of Technostress on End-User Satisfaction and Performance," *Journal of Management Information Systems* (27:3), pp. 303–334.
- Tarafdar, M., Tu, Q., Ragu-Nathan, T. S., and Ragu-Nathan, B. S. 2011. "Crossing to the dark side: Examining Creators, Outcomes, and Inhibitors of Technostress," *Communications of the ACM* (54:9), p. 113-120.
- Vrijkotte, T. G. M., van Doornen,L. J. P., and de Geus,E. J. C. 2000. "Effects of Work Stress on Ambulatory Blood Pressure, Heart Rate, and Heart Rate Variability," *Hypertension* (35:4), pp. 880–886.
- Wastell, D., and Newman, M. 1996. "Information system design, stress and organisational change in the ambulance services: A tale of two cities," *Accounting, Management and Information Technologies* (6:4), pp. 283–300.
- Weil, M. M., and Rosen, L. D. 1997. *TechnoStress*: *Coping with technology @work @home @play*, New York: J. Wiley.
- Wiener, N. 1961. *Cybernetics; or, Control and Communication in the animal and the machine*, New York: M. I. T. Press.

Too Happy to Care? Measuring the Effect of Positive Emotions on Attention and Information Processing

Christoph Schneider, City University Hong Kong, Tillmann Neben, University of Mannheim

Corresponding author: christoph.schneider@cityu.edu.hk

Emotions strongly influence human behaviour. Thus, ecommerce practitioners design artefacts to purposely induce *positive* emotions. Mechanisms such as providing instant upgrades, automatic application of "best available coupons", as well as quizzes, games, and raffles that are embedded into the shopping process are designed to create a positive consumer experience, positively influencing outcomes such as *purchase intention*, *satisfaction*, and ultimately, *loyalty*. This topic is especially relevant to the IS discipline, as emotions have a strong effect on the processing and absorption of *information*. In particular, the literature predicts that positive emotions can influence **attention** placement and information **processing intensity**. Interestingly, theory predicts two different and conflicting effects of positive emotions on human information behavior. On the one hand, the broaden-and-build theory (Fredrickson et al. 2005) predicts positive emotions to cause increased attention and more intensive processing (H1). On the other hand, explanations based on Tamir and Robinson (2007) posit that positive emotions may actually lead to decreased attention (H2). Additional support for this hypothesis is based on *confidence* effects induced by positive emotions (Petty et al 2002). Because this theoretical conflict has strong academic as well as practical implications, we test both predictions in a series of controlled laboratory experiments. In our first experiment we used a simulated online store to test the hypothesis that positive emotions *increase* attention against the hypothesis that positive emotions *decrease* attention. We recruited participants at a university in Hong Kong (n=12), and directed them to a website that mimicked a well-known local supermarket delivery service, were they had to select snacks for a picnic. After selecting the items, the participants proceeded to a checkout page that listed all items in the basket and asked for final confirmation. We induced positive emotions (the IV) by forwarding the treatment group to a wheel-of-fortune game for winning a 50HKD (~5€, 8USD) voucher before they reached the checkout page. Winning chances were indicated to be 15%, but we manipulated the game so that all participants in the treatment group actually won. The non-treatment group was not forwarded to the game. In order to rule out memory effects due to differences in duration of the process, we included a waiting dialog in the non-treatment group. To assess *attention* (the DV), we added an unwanted item ("Fish Balls") to the shopping basket (Figure 1, right), and recorded whether the participants realized the item's presence before placing the order.

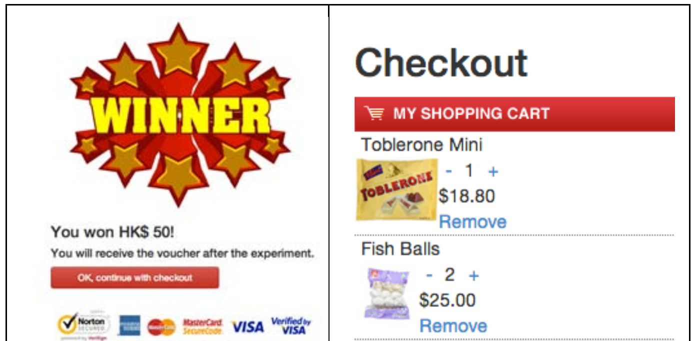


Figure 1. Treatment stimulus (left), measure of attention (right).

To provide a preliminary test of our hypotheses, we apply the following logic: If the treatment group realizes the presence of an unwanted item more often than the control group, H1 would be supported. If the treatment group realizes the presence of an unwanted item less often than the control group, H2 would be supported. We used **facial electromyography** (fEMG) as manipulation check for the independent variable. Using a custom script, we recorded a marker at stimulus onset (Figure 1, left side, notification of winning), and recorded the activity of the zygomaticus major muscle (which is involved in smiling and the expression of other positive affect) using a Psychlab EMG2 system. We compared each participant's zygomaticus activity against his or her baseline activity. Early results indicate hat we successfully manipulated positive affect, but did not find meaningful differences between participants in terms of attention. Given the subjects' familiarity with the task, it is likely that our way of assessing attention was overly noticeable. For the next phase of this ongoing work, we plan to modify the task, fully incorporate the three distinct networks of attention (alerting, orienting, and executive attention), and include an additional dependent variable besides *attention*; specifically, we will use the analysis of eye movements and fixations as a measure of *information processing*.

References

❖ Fredrickson, B. L., and Branigan, C. 2005. "Positive emotions broaden the scope of attention and thought-action repertoires," Cognition & Emotion (19:3), pp. 313–332.

❖ Tamir, M., and Robinson, M. D. 2007. "The Happy Spotlight: Positive Mood and Selective Attention to Rewarding Information," Personality and Social Psychology Bulletin (33:8), pp. 1124–1136.

❖ Petty, R. E., Briñol, P., and Tormala, Z. L. 2002. "Thought confidence as a determinant of persuasion: The self-validation hypothesis," Journal of Personality and Social Psychology (82:5), pp. 722–741.

Technostress-Induced Distorted Pre-Adoption Beliefs

Christian Maier (University of Bamberg), Sven Laumer (University of Bamberg)

Corresponding author: sven.laumer@uni-bamberg.de

Imagine that an individual has to accomplish a task with a new information system (IS). Even if first research results indicate that strain reduces an individual's intention to use an IS continuously (Maier et al. 2014), reasons have not been investigated how such behavioral responses, which are mainly influenced by perceptual beliefs (Davis 1989), arise from being strained. In this paper, we theorize that a highly strained individual develops distorted perceptual beliefs which are in turn a starting point for developing intentions not to adopt an IS. Hence, the research question of this article is: *How does strain while using an IS for the first time influence perceptual beliefs about and the intention to adopt this IS?*

The person-environment (P-E) fit model is a widely accepted and used theoretical paradigm in stress research (Cooper et al. 2001). The model characterizes strain as a result of the misfit between characteristics of an individual and its environment. This misfit arises when an individual's abilities do not match the demands of the environment. One application of this model in IS research is the confrontation of an individual with a new IS. According to the P-E fit model, an individual is strained when the subjective evaluation of the demands to use the IS does not fit with the individual's skills to use it. Based on this subjective evaluation an individual might be strained (Ayyagari et al. 2011).

An individual aims to keep the degree of being strained at a minimum level. This means that strain has no effect on an individual while one is not strained, whereby a strained individual intends to reduce it when it is present. As a consequence, being strained is accompanied by the desire to change something about this situation. Whenever strain is grounded in the usage of a new IS, an individual is evaluating its characteristics and develops perceptual beliefs within a negative emotional state. As an individual aims to change the negative perception of being strained, the development of one's perceptual beliefs is distorted negatively by the IS-induced strain (Taylor 1991). This means that the perceptual belief being developed in this negative emotional state is worse than it would be without this state. Such perceptual beliefs which are influenced by an individual's emotional state are named distorted beliefs (Turel et al. 2011). In this context, it is important that individuals tend to pay more attention to negative experiences than to positive ones (Ito et al. 1998). As a consequence we assume that the evaluation of the IS by a strained individual is distorted and these distorted perceptual beliefs are the base for developing an intention to adopt the IS. Due to an individual's reason-based decisions, the intentions to adopt an IS of strained individuals are lower than the intentions to adopt a new IS of an individual who does not feel strained. Figure 1 summarizes our theoretical nomological network of the influence of strain on distorted perceptual beliefs and consequently the initial adoption as well as the continuous usage decision

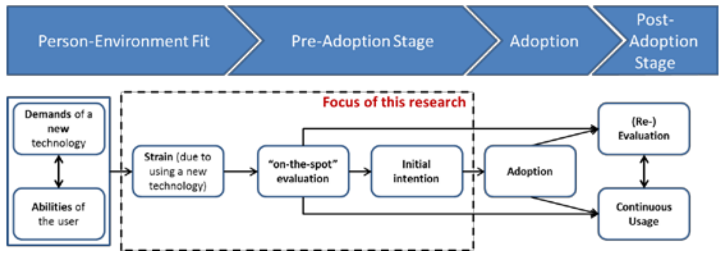


FIGURE 1: DISTORTED BELIEFS IN PRE-ADOPTION STAGES

To validate the proposed distorting influence of strain on beliefs we intend to set up an experiment by using NeuroIS measurements. Individuals, who have not used a specific enterprise content management system (Laumer et al. 2013) before, have to accomplish tasks with this system. During the experiment the participants' level of electrodermal activity (EDA) as one NeuroIS indicator of strain is measured. After the experiment beliefs and intentions related to the IS are captured using a survey.

Based on the expected results we intend to contribute to IS research by theorizing strain as an inhibiting variable that distorts IS-related beliefs at the pre-adoption stage. This increases the understanding of how and why individuals use IT. Using NeuroIS in IS adoption research might also open the black box (Benbasat and Barki 2007) in this branch of research by explaining how physiological responses influence the development of beliefs when using a new IS for the first time.

References

- Ayyagari, R., Grover, V., and Purvis, R. 2011. "Technostress: Technological Antecedents and Implications", MIS Quarterly (35:4), pp. 831–858.
- Benbasat, I., and Barki, H. "Quo vadis, TAM?," Journal of the Association for Information Systems (8:4), April 2007, pp. 211-218.
- Cooper, C. L., Dewe, P., and O'Driscoll, M. P. 2001. Organizational stress: A review and critique of theory, research, and applications, Thousand Oaks, Calif: Sage.
- Davis, F. D. 1989. "Perceived Usefulness, Perceived Ease of Use and User Acceptance of Information IS," MIS Quarterly (13:3), pp. 319–340.
- Ito, T. A., Larsen, J. T., Smith, N. K., and Cacioppo, J. T. 1998. "Negative information weighs more heavily on the brain: The negativity bias in evaluative categorizations," Journal of Personality and Social Psychology (75:4), pp. 887–900.
- Laumer, S., Beimborn, D., Maier, C., and Weinert, C. 2013. "Enterprise Content Management," Business & Information Systems Engineering (5:6), pp. 449–452.
- Maier, C., Laumer, S., Eckhardt, A., and Weitzel, T. 2014. "Giving too much Social Support: Social Overload on Social Networking Sites," European Journal of Information Systems. forthcoming
- Taylor, S. E. 1991. "Asymmetrical Effects of Positive and Negative Events: The mobilization-minimization hypothesis," Psychological Bulletin (110:1), pp. 67–85.
- Turel, O., Serenko, A., and Giles, P. 2011. "Integrating IS Addiction and Use: An Empirical Investigation of Online Auction Users," MIS Quarterly (35:4), pp. 1043–1061.

Technostress-Induced SCR Patterns and Performance

Christoph Weinert, University of Bamberg, Christian Maier, University of Bamberg, Sven Laumer, University of Bamberg

Corresponding author: christoph.weinert@uni-bamberg.de

Prior research reveals that performance between individuals under stress varies (Matthews 2000). Differences in technostress-induced physiological responses might lead to a different end-user performance. Therefore, this research in progress aims to analyze technostress-induced skin conductance response (SCR) patterns and whether these patterns lead to different end-user performances.

Using stressful technology influences an individual's physiology through affective and cognitive processes and basic brain mechanisms. Research shows that such usage causes an increase in the activity of human sweat glands through multiple brain mechanisms (Randolph et al. 2005). SCR is a well-established measurement method for stress (Boucsein 2012) and has been used to measure technostress (Eckhardt et al. 2012; Riedl et al. 2013).

Burk (2005) determines based on various SCR courses four different SCR patterns. The patterns describe the SCR course after the stressor is triggered. To actually determine the patterns Burk (2005) divides the SCR course after the stressor onset in three different blocks of five reactions each and calculates the mean values. By interpreting the mean values of each block Burk (2005) identifies four response patterns. The first is characterized by the strongest and highest reaction in the first block followed by a constant decrease over block two and three (pattern A). The second follows the shape of an inverted U-curve (pattern B). The third is characterized by a general increase of the reaction in which the reaction is lowest in the first block and increases constantly over block two and three (pattern C). The fourth is shaped as a U-curve (pattern D). Patterns A and B can be summarized as regular reaction courses because despite the temporal awareness within pattern B the reactions decrease, whereas patterns C and D are determined as irregular reaction courses, because the response increases rather than decreases. All patterns are displayed in Figure 1.

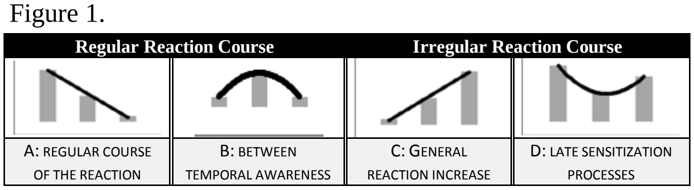


FIGURE 1: SKIN CONDUCTANCE REACTION PATTERNS

Technostress research claims that end-user performance is negatively influenced by technological stressors (Maier et al. 2014, Tarafdar et al. 2010). Thereby, prior research shows that negative consequences of technology usage such as low performance can be mitigated by stabilizing the negative reactions towards the technology (Beaudry and Pinsonneault 2005), such that we argue that individuals who recover from technostress perform better than those who show an increase in their technostress level. Therefore, we assume that individuals who respond in a regular pattern A or B perform better than those who follow the irregular reaction patterns.

To provide first indicative evidence for this proposition we conducted a laboratory experiment. We captured the SCR of 18 participants while working with an unreliable computer, which froze for one minute. We analyzed the first 15 seconds of the SCR after the computer froze to determine the SCR patterns as described by Burk (2005). In addition, end-user performance was calculated by assessing the task results into faulty and correct results, and we analyzed the values of the time needed to accomplish the task.

The results of our pilot study indicate that the subjects react differently towards technostress. In general, 7 out of 18 (39%) react in a regular pattern A or B, whereas 11 out of 18 (61%) follow an irregular reaction course C or D. The majority of the participants followed the irregular pattern C. Results also show differences in the end-user performance. For example, subjects who followed pattern C indicate the best performance, whereas the participants that showed pattern D demonstrate the lowest performance. In addition, the subjects who respond in a regular pattern A and B perform worse, than those who respond in an irregular reaction in terms of pattern C and D. In conclusion, our first results demonstrate that we found no support for the developed proposition in our pilot study, which might be explained by the small sample. Despite the mean comparison results, we will realize a lager laboratory experiment in order to test the proposition with adequate statistical methods. By extending this experiment we intend to contribute to IS research by showing that technostress-induced physiological responses influence end-user performance and by explaining in-depth how technostress influences end-user performance through the mediation of physiological responses in terms of the SCR patterns.

References

- Beaudry, A., and Pinsonneault, A. 2005. "Understanding User Responses to Information Technology: A Coping Model of User Adaptation," *MIS Quarterly* (29:3), pp. 493–524.
- Boucsein, W. 2012. *Electrodermal Activity*, New York: Springer Science+Business Media, LLC.
- Burk, C. L. 2005. *Phasische Elektrodermale Aktivität als Persönlichkeitsindikator*.
- Eckhardt, A., Maier, C., and Buettner, R. 2012. "The Influence of Pressure to Perform and Experience on Changing Perceptions and User Performance: A Multi-Method Experimental Analysis," *ICIS 2012 Proceedings Proceedings of the 33rd International Conference on Information Systems*.
- Maier, C., Laumer, S., Eckhardt, A., and Weitzel, T. 2014. "Giving Too Much Social Support: Social Overload on Social Networking Sites," Forthcoming in: European Journal of Information Systems.
- Matthews, G. 2000. *Human Performance*: *Cognition, Stress, and Individual Differences*, Hove, East Sussex, Philadelphia, PA: Psychology Press; Taylor& Francis Group.
- Randolph, A. B., McCampbell, L. A., Moore, M. M., and Mason, S. G. 2005. "Controllability of Galvanic Skin Response," *Proceedings of the International Conference on Human-Computer Interaction*.
- 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.
- Riedl, R., Kindermann, H., Auinger, A., and 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 Interactions* (2013), pp. 1–7.
- Tarafdar, M., Tu, Q., and Ragu-Nathan, T. S. 2010. "Impact of Technostress on End-User Satisfaction and Performance," *Journal of Management Information Systems* (27:3), pp. 303–334.

Neural Features of Video Topical Relevance

Luísa R. Pinto[1], Yashar Moshfeghi[1], Frank E. Pollick[2], Joemon M. Jose[1]
School of Computing Science[1], School of Psychology[2], University of Glasgow
L.Pinto.1@research.gla.ac.uk; [Yashar.Moshfeghi|Frank.Pollick |Joemon.Jose]@glasgow.ac.uk

For over 50 years, Information Retrieval Systems (IRSs) have been helping users to find relevant information. However, IRSs often retrieve non-relevant information causing user dissatisfaction. Relevance therefore has become a key concept for IRS building and evaluation. Research in this area used to be centred in a system view of relevance, but since it has become widely accepted that relevance is a human perception (Saracevic, 1996), the research on relevance has moved to a user view of relevance (Mizzaro, 1997), focusing on relevance in the world of the user - such as the way users assess relevance depending on the problem at hand, context and criteria. However, as any other human perception, relevance is an elusive one (Saracevic, 1996). Researchers therefore continue to investigate the human nature of relevance. For instance, advances in Neuroimaging have allowed researchers to look at relevance from a neuroscience perspective. Moshfeghi et al. (2013) have conducted a seminal fMRI study to investigate the neural correlations of relevance. They used a block design to find the brain regions that activate during the task of image topical relevance assessments. Their results have shown three regions (i.e. inferior parietal lobe, inferior temporal gyrus and superior frontal gyrus) where activity was significantly greater during the assessment of the relevant images. These three regions were located in the right hemisphere of the brain. However, it has been suggested that if text was used instead of images, brain activations could possibly be located in the left hemisphere of the brain. Subsequently, Gwizdka (2013) have used event-related fMRI to investigate the brain activity during assessments of relevance of individual words to news articles. Based on preliminary results, it has been suggested that different levels of brain activity could be related to different levels of relevance. However, it is unclear where such activations occurred. Despite the importance of prior studies, more research is needed in order to deeply understand the neural bases of relevance. In addition, fMRI studies design and stimuli choices can have significant impact on the measured fMRI signals (Amaro et al., 2006). Therefore, our idea is to use video stimuli in a stochastic rapid-event related fMRI study to find regions where activity patterns relate to video relevance. We designed our study carefully to allow a more realistic scenario without losing statistical power (Dale, 1999). In addition, we aim to investigate the extent to which it is possible to predict the relevance of individual stimulus from brain features. In contrast, prior studies have looked at the average response to the whole set of stimulus. The following are our two major research questions. *(RQ1)* What are the brain mechanisms of video relevance judgement? *(RQ2)* Can we use brain features to predict relevance? To answer our RQs, we performed a controlled user study where 24 subjects judged the relevance of videos during 3 predefined search tasks that were selected from the TREC 2002 Video Track (Topic IDs: 79, 80, 82). The experiment, which followed a within-subjects design, has one independent variable that is the relevance or non-relevance of videos. It has also two dependent variables: (1) the level of activation when answering RQ1; and (2) the video relevance prediction accuracy when answering RQ2. A schematic representation of the optimised design is provided in Figure 1.

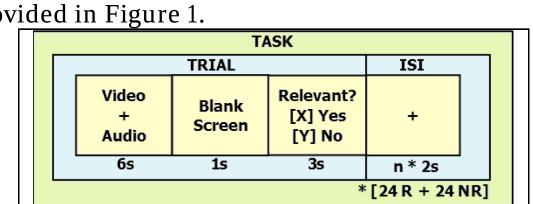


Figure 1. Design scheme for a task.

We are performing activity based analysis of our data with Brain Voyager QX 2.8 (Goebel et al., 2006) and information based analysis with PyMVPA (Hanke et al., 2009). We expect to find activations in the right and left hemispheres of the brain. In addition, we believe that the best region for predicting relevance may vary across subjects. Our work will have two major contributions: (1) to provide a neuroscience perspective of video relevance assessments; and (2) to determine whether brain features can be used as a source for relevance feedback.

References

- Amaro Jr, E., & Barker, G. J. (2006). Study design in fMRI: basic principles. Brain and cognition, 60(3), pp. 220-232.
- Dale, A. M. (1999). Optimal experimental design for event-related fMRI. Human brain mapping, 8(2-3), pp. 109-114.
- Goebel, R., Esposito, F. & Formisano, E. (2006) Analysis of FIAC data with BrainVoyager QX: From single-subject to cortically aligned group GLM analysis and self-organizing group ICA. Human Brain Mapping, 27, 5, pp. 392–401.
- Gwizdka, J. (2013) Looking for Information Relevance in the Brain. In Gmunden Retreat on NeuroIS 2013, p. 14.
- Hanke, M., Halchenko, Y. O., Sederberg, P. B., Hanson, S. J., Haxby, J. V. & Pollmann, S. (2009). PyMVPA: A Python toolbox for multivariate pattern analysis of fMRI data. Neuroinformatics, 7, pp. 37-53.
- Mizzaro, S. (1997). Relevance: The whole history. Journal of the American society for information science, 48(9), pp. 810-832.
- Moshfeghi, Y., Pinto, L. R., Pollick, F. E., & Jose, J. M. (2013) Understanding relevance: An fMRI study. In ECIR, pp. 24-27.
- Saracevic, T. (1996). Relevance reconsidered. In CoLIS 2, pp. 201-218.

Analyzing Mental Workload States on the Basis of the Pupillary Hippus

Ricardo Buettner, mis-Institute at FOM University of Applied Sciences Munich,
ricardo.buettner@fom.de

In the following I report promising results from an initial experiment which applies a novel method for determining a user's mental workload state based on the analysis of pupillary Hippus using eye-tracking technology during human-computer interaction (HCI).

Since evaluating mental workload states from observing the human pupillary is an objective, cheap, non-invasive and efficient method, well established in psychology (Beatty 1982), eye-tracking based pupillometry is a promising method in information systems (IS) research, especially in NeuroIS and HCI (e.g., Buettner et al. 2013). However, prior research has mainly focused on static parts of the pupillary response (e.g., diameter values) and very little research exists that considers the phasic parts (frequency domain) of the pupillary responses.

The so-called pupillary Hippus which describes the oscillating pupillary unrest was completely neglected in IS research, although it is known that this Hippus is strongly linked to a user's mental workload (Bouma and Baghuis 1971).

Initially Stark et al. (1958) observed the continuous small fluctuations of the human pupil around a frequency of 0.2 Hz (so-called pupillary Hippus, tremor, or unrest). Campbell et al. (1959) figured out that the relevant bandwidth of this pupillary Hippus is at 0-0.5 Hz. Bouma and Baghuis (1971) then found that mental activity causes an immediate disappearance of Hippus.

This sparked my interest in investigating whether mental workload states could be derived from pupillary Hippus data. To this end I conducted a within-participant designed experiment which was divided into two sequential parts – first a workload intensive part, subsequently followed by a relaxation part. For the workload intensive part I employed a well-documented task from psychology. According to (Beatty 1982), participants memorize and reproduce numbers from three to nine digits. For the relaxation part I applied the progressive relation technique (cf. Scheufele 2000) using music and imagery from the 2006 football World Cup.

To capture the pupil of both participants' eyes I used the binocular double EyegazeEdgeTM System eye-tracker (2*60Hz, 19'' LCD monitor (86 dpi) at 1280x1024).

Analysing the frequency domain of the pupillary signal I hypothesized lower power values of the Hippus relevant bandwidth of 0-0.5 Hz at the workload state (memorizing/reproducing task) compared to the relaxation state (relaxing music and imagery task) [H1]. Twelve volunteers (six females) aged from 21 to 38 (M=26.2, SD=4.1) participated. As a result, the power values of the Hippus relevant band shown in Table 1 were significantly greater at the relaxation state compared to the workload state (t-tests, $p_{left\ eye}<.001$, $p_{right\ eye}<0.001$) which confirms hypothesis [H1].

Table 1. Results of the Hippus relevant bandwidth (0-0.5 Hz) power (in system units) calculated with MathWorks MATLAB R2014a. Values are normally distributed (Kolmogorov-Smirnov test).

	Workload state		Relaxation state	
	left eye	right eye	left eye	right eye
S1	2.8669	2.9290	3.8536	4.2951
S2	2.5441	2.4849	2.9652	3.0227
S3	1.7474	1.6923	2.3802	2.3098
S4	1.7622	1.8512	1.8720	1.9319
S5	2.1604	2.2474	2.4181	2.5383
S6	2.4541	2.6285	3.1042	3.3289
S7	1.7078	1.7017	2.2433	2.1504
S8	2.6755	2.8433	3.8871	4.1757
S9	3.1024	3.3780	3.7967	4.2462
S10	1.9641	2.1149	2.9128	3.0162
S11	1.6441	1.6580	2.5925	2.6767
S12	2.0034	1.7508	2.4776	2.1748
M	2.2194	2.2733	2,8753	2,9889

Since I found large effect sizes (Cohens $d_{left\ eye} = 1.109$, $d_{right\ eye} = 0.980$; effect size $r_{left\ eye} = 0.485$, $r_{right\ eye} = 0.440$), the method of analysing the pupillary Hippus in order to identify the users mental workload is very promising for IS research, especially in NeuroIS and HCI, but needs further experimental evaluation.

References

❖ Beatty, J. 1982. Task-Evoked Pupillary Responses, Processing Load, and the Structure of Processing Resources. Psychol Bull, 91(2), pp. 276-292.
❖ Buettner, R., Daxenberger, B., Eckhardt, A., and Maier, C. 2013. "Cognitive Workload Induced by Information Systems: Introducing an Objective Way of Measuring based on Pupillary Diameter Responses," *Pre-ICIS HCI/MIS 2013 Proceedings*, Paper 20.
❖ Bouma, H., and Baghuis, L. 1971. "Hippus of the pupil: Periods of slow oscillations of unknown origin," *Vision Research* 11(11), pp. 1345-1351.
❖ Campbell, F., Robson, J., and Westheimer, G. 1959. "Fluctuations of accommodation under steady viewing conditions," *J Physiol* 145(3), pp. 579-594.
❖ Scheufele, P. 2000. "Effects of Progressive Relaxation and Classical Music on Measurements of Attention, Relaxation, and Stress Responses," *J of Behavioral Medicine* 23(2), pp. 207-228.
❖ Stark, L., Campbell, F., and Atwood, J. 1958. "Pupil unrest: an example of noise in a biological servomechanism," *Nature* 182(4639), pp. 857-858.

The Role of the Repetition Suppression Effect in User Disregard of Security Warnings: An fMRI Study

Bonnie Brinton Anderson, Brigham Young University (BYU), Anthony Vance, BYU, C. Brock Kirwan, BYU, David Eargle, University of Pittsburgh, Seth Howard, Google.

Corresponding author: bonnie_anderson@byu.edu

Warning messages are one of the last lines of defense in computer security, and are fundamental to users' security interactions with technology (Figure 1). Unfortunately, experimental research has consistently shown that security warnings are largely ineffective (Wu et al. 2006). A key contributor to pervasive user disregard of security warnings is *habituation*, the diminishing of attention due to frequent exposure to a warning. (Kalsher and Williams 2006). Furthermore, the habituation process can be accelerated if no negative consequence is experienced when a warning is ignored (Vredenburgh and Zackowitz 2006). Although previous security literature has examined habituation of security warnings, it has done so indirectly, by observing the influence of habituation on security behavior, rather than measuring habituation itself.

This study seeks to contribute by using neuroscience to open the "black box" of the brain to observe habituation as it occurs. Specifically, we point to the repetition suppression (RS) effect, the reduction of neural responses to stimuli that are viewed repeatedly, a phenomenon directly antecedent to the process of habituation. By investigating how repetition suppression occurs in the brain, we can make a more precise approach to designing security warnings that are resistant to, or possibly can even reverse the effects of habituation. For example, *polymorphic* warnings, or warnings that repeatedly change their appearance, are expected to reduce the effects of habitation (Brustoloni and Villamarín-Salomón 2007). We propose a series of three laboratory experiments using functional magnetic resonance imaging (fMRI) to observe brain data and improve user interaction with security warnings.

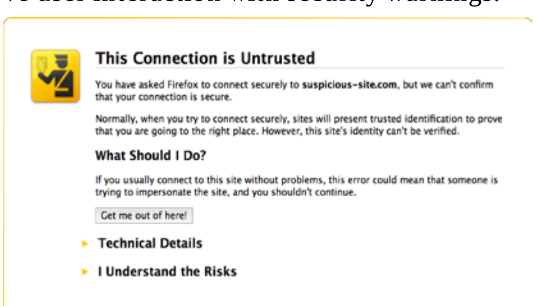


Figure 1: SSL Security Warning

A method of choice in decision neuroscience is fMRI because of its superior ability to identify areas of the brain that are activated during decision making and other behavioral tasks (Dimoka et al. 2012).

We propose three fMRI experiments to examine a variety of research questions on how the RS effect is exhibited in the brain, how it changes over time, and how it affects security warning disregard behavior.

- ❖ Experiment 1: fMRI with Static Images of Warnings
  - ❖ H1: The BOLD response will decrease in regions sensitive to repetition during the course of the experiment.
- ❖ Experiment 2: fMRI with Static Images of Polymorphic Warnings
  - ❖ H2: Polymorphic security warnings will exhibit lower levels of RS than static security warnings.
- ❖ Experiment 3: Longitudinal fMRI with Static Images of Warnings
  - ❖ H3: BOLD responses will continue to decrease in the ventral visual processing stream and medial temporal lobe regions but will increase in the basal ganglia with long-term repeated exposure to security warnings.

By studying the onset of RS in the brain, this study has the potential to more precisely remediate the problem of habituation to security warnings. The ultimate promise of applying neuroscience to behavioral information security is to use insights from the study of the brain to design effective user interfaces that can help users make informed decisions (Riedl et al. 2010). In this study, we propose to use our fMRI experiments to guide the design and testing of polymorphic warnings. Additionally, we anticipate that our findings will demonstrate the usefulness of applying neuroscience to the domain of behavioral information security.

REFERENCES

❖ Brustoloni, J. C., and Villamarín-Salomón N, R. Improving security decisions with polymorphic and audited dialogs. In SOUPS '07: Proceedings of the 3rd symposium on Usable privacy and security (New York, NY, USA, 2007), ACM Press, pp. 76–85.

❖ Dimoka, A., Banker, R. D., Benbasat, I., Davis, F. D., Dennis, A. R., Gefen, D., Gupta, A., Ischebeck, A., Kenning, P. H., Pavlou, P. A., Müller-Putz, G., Riedl, R., Brocke, vom, J., and Weber, B. 2012. "On The Use Of Neurophysiological Tools In Is Research: Developing A Research Agenda For NeuroIS," *MIS Quarterly* (36:3), pp. 679–A19.

❖ Kalsher, M.J. and Williams, K.J 2006. Behavioral compliance: theory, methodology, and results. In M. S. Wogalter, editor, Handbook of warnings, chapter 23, pages 313–329. Mahwah, New Jersey.

❖ Riedl, R., Randolph, A. B., Brocke, vom, J., Leger, P., and Dimoka, A. 2010, December 12. "The Potential of Neuroscience for Human-Computer Interaction Research," *Special Interest Group on Human-Computer Interaction.*

❖ Vredenburgh, A. G., & Zackowitz, I. B. (2006). Expectations. *Handbook of Warnings*, 345-354.

❖ Wu, M., Miller, R. C., & Garfinkel, S. L. (2006, April). Do security toolbars actually prevent phishing attacks? In Proceedings of the SIGCHI conference on Human Factors in computing systems (pp. 601-610). ACM.

Supporting Institutions and Journals