Lecture Notes in Information Systems and Organisation 58

Fred D. Davis · René Riedl ·
Jan vom Brocke · Pierre-Majorique Léger ·
Adriane B. Randolph ·
Gernot R. Müller-Putz *Editors*

Information Systems and Neuroscience

NeuroIS Retreat 2022

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Editors

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Editors
Fred D. Davis
Information Technology Division
Texas Tech University
Lubbock, TX, USA

Jan vom Brocke
Department of Information Systems
University of Liechtenstein
Vaduz, Liechtenstein

Adriane B. Randolph
Department of Information Systems
and Security
Kennesaw State University
Kennesaw, GA, USA

René Riedl
Digital Business Institute
University of Applied Sciences Upper
Austria
Steyr, Austria

Institute of Business
Informatics—Information Engineering
Johannes Kepler University Linz
Linz, Austria

Pierre-Majorique Léger
Department of Information Technologies
HEC Montreal
Montréal, QC, Canada

Gernot R. Müller-Putz
Institute of Neural Engineering
Graz University of Technology
Graz, Austria

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Preface

The proceedings contain papers presented at the 14th annual NeuroIS Retreat held June 14–16 2022. NeuroIS is a field in Information Systems (IS) that uses neuroscience and neurophysiological tools and knowledge to better understand the development, adoption, and impact of information and communication technologies (www.neurois.org).

The NeuroIS Retreat is a leading academic conference for presenting research and development projects at the nexus of IS and neurobiology. This annual conference promotes the development of the NeuroIS field with activities primarily delivered by and for academics, though works often have a professional orientation.

In 2009, the inaugural NeuroIS Retreat was held in Gmunden, Austria. Since then, the NeuroIS community has grown steadily, with subsequent annual Retreats in Gmunden from 2010 to 2017. Beginning in 2018, the conference is taking place in Vienna, Austria. Due to the Corona crisis, the organizers decided to host the NeuroIS Retreat virtually in 2020 and 2021. This year, the NeuroIS Retreat took place again in a physical face-to-face-format in Vienna.

The NeuroIS Retreat provides a platform for scholars to discuss their studies and exchange ideas. A major goal is to provide feedback for scholars to advance their research papers toward high-quality journal publications. The organizing committee welcomes not only completed research but also work in progress. The NeuroIS Retreat is known for its informal and constructive workshop atmosphere. Many NeuroIS presentations have evolved into publications in highly regarded academic journals.

This year is the 8th time that we publish the proceedings in the form of an edited volume. A total of 35 research papers were accepted and are published in this volume, and we observe diversity in topics, theories, methods, and tools of the contributions in this book. The 2022 keynote presentation entitled “The Neurobiology of Trust: Benefits and Challenges for NeuroIS” is given by Frank Krueger, professor of systems social neuroscience at the School of Systems Biology at George Mason University (GMU), USA. Moreover, Jan vom Brocke, professor of information systems at the University of Liechtenstein, gives a hot topic talk entitled “From Neuro-adaptive

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

Altogether, we are happy to see the ongoing progress in the NeuroIS field. Also, we can report that the NeuroIS Society, established in 2018 as a non-profit organization, has been developing well. We foresee a prosperous development of NeuroIS.

Lubbock, USA	Fred D. Davis
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The Neurobiology of Trust: Benefits and Challenges for NeuroIS (Keynote)

Frank Krueger

Trust pervades nearly every aspect of our daily lives; it penetrates not only our human social interactions but also our interactions with information and communication technologies (ICTs). The talk provides an overarching neurobiological framework of trust—focusing on empirical, methodological, and theoretical aspects—that serves as a common basis for the broad and transdisciplinary community of trust research. The integration into a unified conceptual framework of trust can guide future investigations to better understand both fundamental and applied NeuroIS research in developing new theories and designing innovative ICT artifacts that positively affect practical outcomes for individuals, groups, organizations, and society.

From Neuro-adaptive Systems to Neuro-adaptive Processes: Opportunities of NeuroIS to Contribute to the Emerging Field of Process Science (Hot Topic Talk)

Jan vom Brocke

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

Contents

Our Brain Reads, While We Can't: EEG Reveals Word-Specific Brain Activity in the Absence of Word Recognition

Peter Walla, Robin Leybourne, and Samuil Pavlevchev

Abstract This electroencephalography (EEG) study provides significant neurophysiological evidence for the processing of words outside conscious awareness. Brain potentials were recorded while 25 participants were presented with words and shapes, each of them with 17, 34, and 67 ms presentation duration times ("no presentation" was included as control condition). Participants were instructed to report whether they have seen anything and if yes, what it was (shape or word). If they saw a word and were able to read it, they were asked to report having read it. Crucially, even though only 2.9% of the 17 ms word presentations were classified as readable, these presentations elicited significant brain activity near the Wernicke area that was missing in the case of 17 ms shape presentations. The respective brain activity difference lasted for about 150 ms being statistically significant between 349 and 409 ms after stimulus onset. It is suggested that this neurophysiological difference reflects non-conscious (i.e., subliminal) word processing. Some aspects of the NeuroIS discipline include text messages and the current findings demonstrate that those text messages can be processed by the nervous system even in the absence of their conscious recognition.

Keywords Subliminal words · EEG · ERPs · Non-conscious processing

P. Walla (✉)
Faculty of Psychology, Freud CanBeLab, Sigmund Freud University, Freudplatz 1, 1020 Vienna, Austria
e-mail: peter.walla@sfu.ac.at

Faculty of Medicine, Sigmund Freud University, Freudplatz 3, 1020 Vienna, Austria

School of Psychology, Centre for Translational Neuroscience and Mental Health Research, University of Newcastle, University Drive, Callaghan, NSW, Australia

R. Leybourne
Faculty of Psychology, Webster Vienna Private University, Praterstraße 23, 1020 Vienna, Austria

S. Pavlevchev
Center for Research in Modern European Philosophy (CREMP), Kingston University, Penrhyn Road Campus, Kingston upon Thames, UK

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1 Introduction

Non-conscious brain activities, especially in the context of verbal information processing have long been an interesting focus [1]. For instance, it has been shown that superficially (i.e., alphabetically) encoded words lead to measurable brain activity during their subsequent, repeated presentation reflecting detection of their repeated nature even in the absence of conscious recognition [2, 3]. This has been interpreted as non-conscious verbal memory traces. The time window, during which event-related potentials (ERPs) differed between words that failed to be identified as repeated (participant response: "I have not seen this word before"), but were actually presented before, and words that were correctly identified as new (participant response: "I have not seen this word before") was only 200 ms long. While this might seem short, it is long enough to be detected via electroencephalography (EEG), which is known for its excellent temporal resolution due to its direct sensitivity to neurophysiological responses in the brain.

The processing of text (words) in general is of high relevance to the NeuroIS discipline. Verbal stimuli have been used for various investigations [4–6]. Some NeuroIS research successfully used brain imaging tools to study potential effects on trustworthiness perceptions through using text messages like they appear on eBay websites [7].

While in the Rugg et al. study [2] lack of recognition was rather a consequence of low-level attention (due to only alphabetical (letter-based) word encoding during first word exposures), other conditions can cause detectable non-conscious word processing. Such conditions can be related to weak stimulation features like low contrast or short presentation durations. Several early studies demonstrated that short or weak word presentations can still lead to measurable behavioral effects in the absence of awareness [e.g. 8], but only a few studies reported distinct neurophysiological correlates of subliminal word processing. One such study found evidence for neurophysiological traces in response to short word stimulations as short as 1 ms [9]. However, it remains unclear if those traces are indeed specific to subliminal word processing or if they would look similar for other types of stimuli. A very recent study comparing short word presentations with short shape presentations in one experiment was able to show that EEG is indeed capable of detecting word-specific subliminal brain processes [10]. In addition to comparing word with shape processing, this experiment also included varying presentation durations. Words and shapes were visually presented for 17, 34, 67, and 100 ms. Participants had to respond to all stimulus presentations by reporting whether they saw "nothing", a "blur" (something but not sure whether it was word or shapes), a "word", or a "shape" (a string of simple symbols). Crucially, even though recognition for words presented for 17 ms was only 6% (a very insignificant recognition rate), these words elicited brain electrical amplitudes significantly different from those elicited by 17 ms long shape presentations. For their ERP analysis, the authors chose an electrode position located around the well-known Wernicke area, which is commonly understood as a cortical area involved in comprehension, i.e., understanding semantic content [e.g. 11].

The present study was meant to replicate the findings of Pavlevchev et al. [10], while also adding one further condition during which nothing was presented. Besides replicating their results, the hypothesis was that the "nothing" condition should not elicit any processing-related brain electrical amplitudes and could serve as a control condition to compare with both words and shapes. If a physiological difference is detected between the newly introduced control condition and the short 17 ms presentations then this will go to show that despite their insignificant recognition rate of 6%, they are stimuli transduced into neural signals that enter the brain subliminally via the visual system. Finally, the present study asked participants whether they had read the presented word or merely thought it was a word but could not read it.

2 Materials and Methods

2.1 Participants

A total of 25 young adults (10 females and 15 males between the ages of 19 and 27) participated in this study. The mean age of the participants was 22.04 years (SD = 1.99). All participants reported being right-handed, having normal or corrected-to-normal vision, and not having any neuropathological history.

2.2 Stimuli

For this study, the same 30 low-frequency words (6-letters; neutral object nouns) from two databases [12, 13] together with 30 shape stimuli, which were self-created variations of sequences of 6 different simple symbols (same font and contrast as the words) were used as in the Pavlevchev study [10]. Figure 1 shows examples for both stimulus types (taken from [10]).

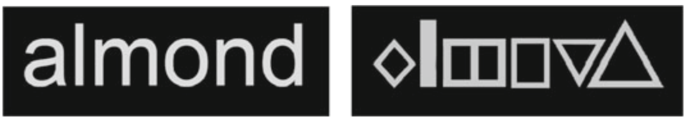

Fig. 1 Examples for word and shape stimulus types (taken from [10])

2.3 Electroencephalography (EEG)

A 64 channel actiCHamp Plus System from Brain Products was used for recording brain electrical signals (in the Freud CanBeLab at Sigmund Freud University in Vienna). The active electrodes were all embedded in an actiCAP connected to the amplifier. The free software PsychoPy 2021.2.3 for Windows was used to design the experiment and to control stimuli delivery to study participants. Brain potential changes were recorded with a sampling rate of 1.000 Hz (filtered: DC to 100 Hz). Offline, all EEG data were down-sampled to 250 Hz and a bandpass filter from 0.1 to 30 Hz was applied.

2.4 Procedure

All stimuli controlled by the software package PsychoPy3 (v2021.1.0) were presented on a computer monitor in random order (stimulus type and duration were randomly varied across presentations). Each presentation (one trial) consisted of a 2 s long "+" symbol (fixation), a 500 ms blank screen, a stimulus (17, 33, or 67 ms), and a 1 s blank screen. The 100 ms duration condition from the Pavlevchev et al. study [10] was left out and replaced by a "nothing" condition for both words and shapes. After each trial, participants were instructed to indicate via a button press, whether nothing, a blur, a shape, a word they could not read, or a word they could read was observed.

2.5 Data Analyses

EEG signal processing was carried out with the EEGDISPLAY 6.4.9 software [14]. Epochs were generated from 100 ms before stimulus onset to 1 s after stimulus onset. The duration of 100 ms prior to stimulus onset was used as a baseline. All epochs with artifacts were automatically excluded. Event-related potentials (ERPs) were calculated for all conditions and re-referenced to the common average across all electrode sites. Finally, only data collected from one electrode location (near the Wernicke area; P7; see Fig. 1) were further processed for this paper.

Behavioral data (button presses) were counted as correct recognition of the stimuli for each condition and then averaged across all participants. Finally, percentages of correct recognitions were calculated.

3 Results

3.1 Behavior

Of all 30 shapes that were presented for 17 ms 22.8% were identified as "I saw a shape". Of all 30 words that were presented for 17 ms 25.9% were classified as "I saw a word". However, across all participants, only 2.9% of all words were classified as "I could read the word".

42.5% of all words that were presented for 34 ms were classified as "I could read the word", and words that were presented for 67 ms were classified as readable at a rate of 71.1%. Of all shapes presented for 34 ms, 68.4% were correctly identified and the correct identification rate for shapes presented for 67 ms was 86%.

The low reading rate for words presented for only 17 ms forms the behavioral basis for this study and is interpreted as more or less a lack of ability to consciously read the word.

3.2 Electroencephalography (EEG)

Visual inspection and direct comparison to the results of the Pavlevchev et al. study [10] reveals a remarkably similar pattern of ERP modifications. The present data, however, displays slightly delayed neural activity that starts from around 350 ms and lasts until 410 ms post-stimulus onset. Whether the delay results from different neural processing or represents an unknown technical issue remains unclear. This means that the temporal aspects (time delay) of the current study need to be dealt with a certain amount of caution. However, the above-mentioned period was further analyzed. A repeated measures ANOVA revealed a significant "duration" (0, 17, 34, 67 ms) times "type" (nothing, word, shape) interaction ($p = 0.040$; Greenhouse–Geisser corrected) for this time window. A following t-test comparing the mean amplitude of the "17 ms word" condition with the mean amplitude of the "17 ms shape" condition revealed a highly significant difference ($p < 0.001$). See Fig. 2 showing all generated and overlaid event-related potentials (ERPs). The most important ERP difference (between both 17 ms presentations) is marked in grey color. It is noteworthy to mention that this effect can also be seen at various surrounding electrode locations (around P7), even in the right hemisphere, but slightly reduced. However, no further statistical analysis was carried out for those other electrode locations.

4 Discussion

First, the findings of this study largely replicate prior results published by Pavlevchev et al. [10], while also showing a clear difference between "no presentation" and all

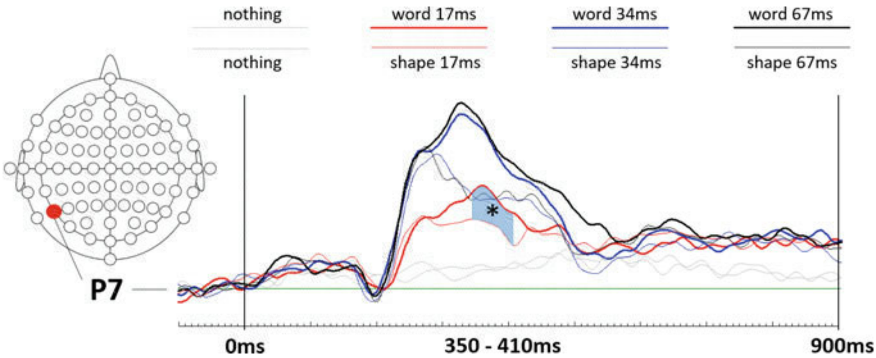

Fig. 2 Event-related potentials (ERPs) overlaid for all eight conditions. Note, that the "nothing" conditions indeed resulted in ERPs similar to the baseline and that the "17 ms word" condition (thick red curve) elicited an ERP significantly different from the ERP elicited by the "17 ms shape" condition (thin red curve)

other presentations. Most importantly, this study also replicates how ERPs elicited by 17 ms shape and word presentations differed significantly in the vicinity of the well-known Wernicke area (comprehension center), which is interpreted as neurophysiological evidence for subliminal word processing. However, it must be noted that this effect in the current study appears slightly later than in the Pavlevchev et al. study [10]. At this point it remains unclear if this delay is of any neurophysiological nature or simply a technical issue, maybe related to some unknown trigger problem. Further, while these authors [10] only asked their participants to report if they have seen a word, in this study, participants were also asked to report if they could read what they believed to have been a word. The 2.9% rate at which participants reported to have read words presented for 17 ms is sufficiently low to assume an overall lack of reading for this short presentation condition. Nevertheless, these shortly presented words elicited brain activity significantly different from that elicited by shapes.

As a next step, non-words should be introduced to this experimental design to test if the found effect is a result of semantic non-conscious (i.e., subliminal) word processing and not a result of only non-conscious (i.e., subliminal) lexical (alphabetical) processing.

Much of the existing literature on subliminal processing reports about respective spatial, physiological correlates related to it [11–14]. We have mainly focused on its temporal aspect and together with existing knowledge about subliminal processing in general, we herewith introduce this fascinating topic to the NeuroIS discipline. NeuroIS research includes constructs that can benefit from insight into how short exposures to some material (e.g. text messages) may enter into or influence information processing in the context of decision making, technology use etc., even at a level below conscious awareness.

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Information Overload and Argumentation Changes in Product Reviews: Evidence from NeuroIS

Florian Popp, Bernhard Lutz, and Dirk Neumann

Abstract Information overload theory suggests that consumers can only process a certain amount and complexity of information. In this study, we focus on product reviews with different complexity in terms of argumentation changes, i.e., alternations between positive and negative arguments. We present the results of a NeuroIS experiment, where participants processed product reviews with low or high rates of argumentation changes. Participants were asked to state their perceived helpfulness of the product review, their purchase intention for the product, and self-reported information overload. During the experiment, we measure cognitive activity based on eye-tracking and electroencephalography (EEG). Our preliminary results suggest that a higher rate of argumentation changes is linked to greater self-reported information overload, and greater cognitive activity as measured by EEG. In addition, we find that greater self-reported overload is linked to lower perceived review helpfulness, and lower purchase intention.

Keywords Product reviews · Information overload · EEG · Eye-tracking

1 Introduction

On modern retailer platforms, product reviews assist customers in their purchase decision-making process [1, 2]. Previous work has demonstrated that reviews that are perceived as more helpful also have a stronger influence on sales numbers [3]. More helpful reviews can further translate to a more positive attitude towards a

F. Popp (✉) · B. Lutz · D. Neumann
University of Freiburg, Freiburg, Germany
e-mail: florian.popp@is.uni-freiburg.de

B. Lutz
e-mail: bernhard.lutz@is.uni-freiburg.de

D. Neumann
e-mail: dirk.neumann@is.uni-freiburg.de

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product [4, 5]. As such, product reviews serve as focal point for the study of human purchase decision-making in information systems (IS) research [1, 6–9].

The questions of what makes helpful product reviews and how certain review characteristics are linked to sales numbers are subject to a large number of publications. Extensive literature reviews are provided by Hong et al. [10] and Zheng [11]. Product reviews consist of a star rating and a textual description [12]. The length of the text and the star rating are among the most studied determinants of review helpfulness [e.g., 6, 13–16]. While existing studies largely agree that longer reviews are perceived as more helpful [e.g., 6, 16], there is less agreement in regard to whether positive or negative reviews are perceived as more helpful. Sen and Lerman [15] find that negative reviews are perceived as more helpful, while the study by Pan and Zhang [17] finds the opposite. Other studies found that consumers perceive reviews of different polarity as more or less helpful depending on factors such as product characteristics [6], review quality [18], review extremity [13], product type [17], and goal orientations [19].

Customers are generally provided with a large number of product reviews [20]. The studies by Park and Lee [21] and Zinko et al. [22] find that, if users are confronted with too many reviews, they can experience information overload. The concept of information overload suggests that a medium amount of information is more helpful for customers' purchase decision-making than little or too much information [23–26]. However, information overload is not only limited to high quantities of information. Instead, information overload can also occur if the presented information exhibits high complexity [27]. While it seems intuitive that information overload can be caused by a large number of product reviews, little is known about whether information overload can also be caused by individual reviews.

In this study, we focus on the line of argumentation in product reviews in regard to how positive and negative aspects are discussed. The line of argumentation in product reviews can be structured in multiple ways. A review can be one-sided, so that it mentions positive or negative aspects only, or two-sided with a mixture of positive and negative arguments. Two-sided reviews can start with positive arguments followed by negative arguments, or vice versa [28]. Such clear cut reviews exhibit only a single argumentation change. As an alternative, the review can alternate between positive and negative arguments, which implies a higher rate of argumentation changes and greater review complexity. We hypothesize that product reviews with a higher rate of argumentation changes (i.e., frequent alternations between positive and negative arguments) are harder to comprehend and that they require greater cognitive effort for being processed. As a consequence, reviews with a high rate of argumentation changes should, in particular, be more likely to cause information overload. In our prior empirical study Lutz et al. [29], we analyzed the link between argumentation changes and review helpfulness solely based on secondary data. In particular, we did not specifically measure (proxies) of information overload as it was considered as a latent construct. The goal of this study is to validate our previous findings in a controlled setting using tools from neuroscience.

We conducted a NeuroIS experiment with eye-tracking and EEG measurements to analyze the effects of a high rate of argumentation changes.[1] Participants were shown product reviews of different products with either low (control group) or high (treatment group) rates of argumentation changes. Subsequently, they were asked to state self-reported information overload, review helpfulness, and purchase intention. Concordant with information overload theory, we find that a higher rate of argumentation changes is linked to greater self-reported information overload and greater cognitive activity as measured by EEG.

2 Research Hypotheses

The term "*information overload*" was coined by Gross [30]. One of the most influential studies on information overload was written by Jacoby et al. [25]. The authors found an inverted U-shape relation between information load and decision outcomes. Within that, consumers make the best choices when being provided with a medium amount of information, and the worst choices when being provided with too little or too much information. The information overload theory is based on the fact that consumers have limited cognitive processing capabilities [31]. Although Jacoby et al. [25], Jacoby [26] and Malhotra [31, 32] produced mixed results regarding the question of whether consumers can truly be overloaded in practice, they all agree that information overload can at least occur in experimental setups. In the area of e-commerce, information overload theory suggests that consumers can process a certain amount and complexity of information during online shopping, and that information which exceeds these capacities leads to poorer purchase decisions [33]. Nowadays, IS researchers largely agree that information overload is a significant issue in e-commerce which needs to be mitigated [34–37].

Interestingly, information overload is not limited to high amounts of information; instead it can also occur when information complexity is high [38, 39]. Otondo et al. [38] and Schneider [39] argue that among others, complexity and ambiguity are possible causes for information overload. For instance, Hiltz and Turoff [27] argue that information might not be recognized as important if it is not sufficiently organized by topic or content. Lurie [40] finds that information should not just be measured by its quantity; instead, it should also account for the information structure. Product reviews are provided in the form of a start rating and a textual description, which describes prior experiences and pros and cons of a product [41, 42]. Reviews can be written in a one-sided, or two-sided way [43, 44]. A two-sided review can, again, be written in several ways, by enumerating pros followed by cons, cons followed by pros, or by interweaving pros and cons [45]. As a motivating example, consider the

[1] An earlier version of this paper was presented at the 17th International Conference on Wirtschaftsinformatik 2022. However, this version only described the experimental design without the results.

following two hypothetical reviews, both evaluating pros (highlighted in light gray) and cons (highlighted in dark gray) of a coffee.

Review A: "This coffee tastes great. However, I don't like the design of its packaging. The smell when opening the bag is awesome. I am a bit disappointed with the strength of it."

Review B: "This coffee tastes great. The smell when opening the bag is awesome. However, I don't like the design of its packaging. I am a bit disappointed with the strength of it."

Both reviews present the same set of pro and contra arguments. Keeping everything else equal, the existing literature on review helpfulness suggests that both reviews are approximately equally helpful as both are of the same length (three sentences), language, and words. However, the rate of argumentation changes in both reviews differs: Review A alternates between positive and negative arguments, whereas Review B presents the content in a more organized manner by discussing positive arguments first and then negative arguments. We argue that a higher rate of argumentation changes increases information complexity [27], which requires more cognitive effort to comprehend the review. Concordant with information overload theory, we expect that a higher rate of argumentation changes increases the cognitive effort that is required to process the review. We therefore propose.

Hypothesis 1a (H1a). A higher rate of argumentation changes in a product review is linked to increased cognitive activity.

Hypothesis 1b (H1b). A higher rate of argumentation changes in a product review is linked to higher self-reported information overload.

Assuming that a higher rate of argumentation changes in a review is likely to cause information overload, we argue that a review with a high rate of argumentation changes is also perceived as less helpful. Additionally, previous work has linked information overload to a reduced consumer experience [46]. For instance, Gross [47] found that information overload could have a damaging effect on the way users view the merchant, and on their commitment to learn about the product's specifications. Another study found that the helpfulness of the information within reviews depends on the readability of the text [48]. Furthermore, previous work has demonstrated a link between helpfulness and sales numbers [3]. Hence, we propose.

Hypothesis 2a (H2a). Greater self-reported information overload is linked to lower perceived helpfulness.

Hypothesis 2a (H2b). Greater perceived helpfulness is linked to higher purchase intention.

Product types can be distinguished between low- and high-involvement products. While low-involvement products feature a lower perceived risk of poor purchase decisions (due to a lower price and less durability), high-involvement products feature a higher price and greater durability, and therefore a higher perceived risk [49]. Consequently, consumers have an incentive to invest more cognitive effort into collecting information (including product reviews) for high involvement products than for low-involvement products. Therefore, one could argue that customers seeking information for high-involvement products are already geared towards investing greater cognitive efforts, so that the (negative) effect of a higher rate of argumentation changes is stronger for low-involvement products. Conversely, one could argue that users prefer well structured high quality reviews when deciding upon buying high-involvement products, which implies a stronger effect of argumentation changes for high-involvement products. Accordingly, we propose two alternative hypotheses.

Hypothesis 3 (H3a). The effect of the rate of argumentation changes on self-reported information overload and cognitive activity is stronger for low involvement products than for high-involvement products.

Hypothesis 3 (H3b). The effect of the rate of argumentation changes on self-reported information overload and cognitive activity is stronger for highinvolvement products than for low-involvement products.

3 Method

3.1 Materials and Treatment

We collect product reviews based on an existing dataset of product reviews from Amazon [50] as this is the prevalent choice in the related literature when studying product reviews (e.g., [6, 12, 16, 51]). We select 16 online reviews for one low-involvement product (Arabica coffee) and 16 reviews for one high-involvement product (a digital camera), which yields a total of 32 reviews. We then manipulate these reviews to exhibit either low or high rates of argumentation changes by changing the order in which positive and negative arguments are presented. For this purpose, we need to remove words and phrases like "Therefore" or "And this is why", while ensuring that the manipulated reviews remain grammatically sound. Product names are removed to account for potential biases against a given brand among the participants.

3.2 Participants, Procedure, and Measures

We recruited 60 subjects via student mailing lists and announcements during lectures. Ethics approval was granted by the University of Freiburg. Each participant receives a fixed compensation of 12 Euros. All students are undergraduates from economics, computer science, or engineering. 28 out of the 60 participants identified as female (46.66%), and 32 as male. The mean age is 24.8 years. The participants are randomly assigned to the treatment (high rate of argumentation changes) or control group (low rate of argumentation changes). Each participant is presented a total of 32 reviews in randomized order. The experimental procedure starts with calibration of the eye-tracking and EEG devices. Before the actual experiment, we perform a test run with a dummy review to make the participants familiar with the general procedure. All product reviews are displayed without any images or product description to avoid potential confounding effects. Participants are given unlimited time for reading a review as we do not intent to induce time pressure. Subsequently, they are asked to state their perceived review helpfulness, the purchase intention, and self-reported information overload on 7-point Likert scales from 1 = low to 7 = high. Finally, participants fill out a survey, where they provide their age, gender, experience with online purchases, and propensity to trust [52].

We measure cognitive activity with EEG and eye-tracking. We use the EMOTIV EPOC X, a 14-channel wireless EEG device, which has been used by a range of previous work [e.g., 53]. As illustrated in Fig. 1, the 14 electrodes are positioned across the scalp. We process the EEG raw data with the following steps using EEGLAB [54]. First, we calibrate the channel location, clean the data by rejecting any unwanted artifacts and noise. Second, we decompose the data by rejecting any unwanted artifacts and noise. Second, we decompose the data by ICA, re-reference the channels to the device's reference channels, filter for alpha wave frequency (8–13 Hz), and define our epochs. Hereby, the epochs were defined as the first 10 s after the review as shown. Third, we determine the alpha wave desynchronization per epoch and participant as a proxy for cognitive load [53, 55–57]. Since a desynchronization of alpha waves results in an overall lower alpha value, lower alpha values indicate greater cognitive activity. For 54 out of 1,888 (ca. 2.9%) observations the signal quality was not sufficient. Thus, we rejected those observations resulting in a dataset comprising 1,834 observations. For the purpose of our cognitive load analysis, we focused on the recordings of the electrode F3, which is positioned on the left prefrontal cortex [53]. In addition, we use the Tobii Pro Fusion eye-tracker to measure the mean fixation duration as a proxy for cognitive load [58]. Hereby, longer fixation durations indicate greater cognitive load. We extract the mean fixation duration with the velocity-based algorithm proposed by Engbert and Kliegl [59].

4 Results

We now present the results from our experiment. We estimate OLS regression models with different dependent variables according to the hypothesis to be tested. We always control for the sequence number of the review in the experiment, the product type, the length of a review in words, the reading time in seconds, and the treatment variable, which equals 1 for reviews with a high rate of argumentation changes (treatment) and 0 for reviews with a low rate of argumentation changes (control).

4.1 Measured Cognitive Activity

We first test hypothesis H1a in regard to the measured cognitive activity. For this purpose, we consider the regression results presented in Table 1. Here, columns (a) and (b) present the results with the mean fixation duration as dependent variable,