

# Editorial: Usage of Social Neuroscience in E-Commerce Research - Current Research and Future Opportunities

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## Introduction

Electronic commerce (e-commerce) has become one of the main drivers of the digital transformation of both national and global economies. e-commerce was defined as a process including both *the sell-buy relationships and transactions* among companies and individuals, and “the corporate processes that support the commerce within individual firms” [17]. E-Commerce, also known as e-business, has become a widespread term in the late 90’s, while it has been present for much longer period of time, from 80’s [16]. Two main types of e-commerce are defined, based on the types of clients: business-to-business (B2B) and business-to-customers (B2C). However, the emergence of social media and peer-to-peer networks enticed the additional type of e-commerce: customers-to-customers (C2C), in which transactions are exchanged not only for money, but also in exchange for personal services or other goods. In addition, due to the prevalent usage of smart-phones, e-commerce has become often referred to as m-commerce [2].

Research area of e-commerce is composed by many scientific disciplines, such as computer science, psychology, economics, and natural sciences, and applied areas, such as marketing, management, finance and engineering [5]. Therefore, e-commerce is a constituent part of the social sciences, which are defined by Merriam Webster Dictionary as a *branch of science that deals with the institutions and functioning of human society and with the interpersonal relationships of individuals as members of society*. Social sciences, like other sciences, are using scientific methods, which are used in order to develop scientific knowledge using a three phase approach: (i) make plausible observations; (ii) interpret these observations in objective manner, and (iii) generalize the interpretations into scientific knowledge. Social sciences use two major groups of methods to investigate human society and individual as members of society: quantitative (e.g. data collected through survey reports), and qualitative (e.g. data collected using interviews or organizational narratives). Scientific methods are required to have the following characteristics: replicability, precision, falsifiability, and parsimony [1]. However, quantitative and qualitative methods traditionally used in social sciences are prone to be vulnerable to different threats to their validity, e.g. sample bias.

Social neuroscience is a method that is using different data generated as the result of the human physiology, in order to “understand the associations and influences between social and biological levels of organization” [4]. NeuroIS has emerged as a new branch of applied social neuroscience, with the goal to use neurophysiological tools for gathering *presumably objective data directly from the human body* for the purpose of information systems research [7]. Two groups of neurophysiological tools are used: (i) psycho physiological tools, such as skin conductance response and eye tracking, and brain imaging tools, such as functional magnetic resonance imaging and electroencephalography, which are often used in combination with the traditional behavioural data sources used in social research. These tools allow the quantification of human reactions to different aspects of information systems, which are the essential part of e-commerce.

In this paper, we investigate to what extent the social neuroscience has been utilized in e-commerce research. We use the systematic approach, searching Scopus database in order to identify the papers in the area of e-commerce that are using neurophysiological tools. Bibliometric analysis has been done, according to type of publication, affiliations, journals and conferences, authors’ countries, and scientific disciplines covered (due to the interdisciplinary of e-commerce research). Papers are analyzed according to the type of neurophysiological tools used, with the goal to trace the most often used tools, and the topics researched with their utilization. Gaps in the current research are identified in order to provide guidance for future research directions.

The paper is organized as follows. The first section provides a specification of used methodology. In the second section the systematic bibliometric analysis is provided. The usage of neurophysiological tools in identified e-commerce research papers is outlined in the third section, with the brief description of their usage and examples of research. The final section provides an overview of research gaps and road to future research.

## Methodology

In the first phase, Scopus database has been searched in order to track papers that describe the usage of neurophysiological tools for the purpose of researching e-commerce topics, e.g. usage of eye tracking for the investigation of the users' habits of searching items on the online shop website [8].

Table 1 outlines the research strategy, that included all types of papers (conference papers, peer-review journal papers, book chapters) indexed in Scopus database in the period from 1997 to 2017.

In the first phase, we searched Scopus in order to detect the papers that have words e-commerce, electronic commerce or m-commerce in the title, abstract or keywords of the paper, which resulted with the 60.241 papers. In the second phase, these papers were refined using the words related to the neuroscience or neurosis or the names of different neuropsychological tools, which results with 155 papers. Finally, in the third phase, these papers were refined by reading the abstracts of the papers in order to detect those that present the specific usage of neurophysiological tools in a specific area of e-commerce, which resulted in 89 papers that are the focus of this research. These papers will be examined in this review in order to provide conclusion to what extent the neuropsychological tools are used as methodological tools in e-commerce research papers. The list of identified papers is available on request from the author.

Table 1: Research strategy for finding papers that describe the usage of neurophysiological tools in a specific area of e-commerce

	Search terms	Number of papers
Scopus database (1997-2017)		
Phase I	TITLE-ABS-KEY e-commerce OR electronic commerce OR m-commerce	60.241 papers
Phase II	Refined by: TOPIC: (neuroscience OR neurois OR eye tracking OR skin conductance response OR SCR OR facial electromyography OR Fmg OR electrocardiogram OR EKG OR functional magnetic resonance OR fMRI OR positron emission tomography OR PET OR magnetocephalography OR MEG OR electroencephalography OR EEG)	155 papers
Manual extraction		
Phase III	Reading of abstracts with the goal to trace research papers that describe the usage of neurophysiological tools in a specific area of e-commerce.	89 papers

Source: Authors' work

## Bibliometric Analysis

Table 2 presents the number of papers according to publication years, source publication, and research area of papers.

Although the Scopus database was searched during the period from 1997 to 2017, the first paper that describe the usage of neuropsychological tools in the area of e-commerce research are detected in 2003 (two papers). In the next two years (2004-2005) there was no publications describing the usage of neuropsychological tools in the area of e-commerce research, while the number of these papers stagnated in the period 2006-2009. The number of publications increased in 2010 to 6 and in 2011 to 7 publications, and after 2012 more than 10 publications per year are published tat investigate the usage of neuropsychological tools in the area of e-commerce research. It can be concluded that the number of publications in this area is increasing, but not yet at the increasing rate.

In order to investigate the multidisciplinary of the papers, they were also analysed according to the research area assigned to papers as part of the Scopus indexation process. Most of the papers were classified as Computer Science papers. Other areas that are represented with more than 10 papers are: Business, Management and Accounting (20 papers), Mathematics (16 papers), Decision Sciences (13 papers), and Social Sciences (12 papers). Other areas are represented with substantially lower number of papers. These findings indicate that paper that develop their research findings in the area of e-commerce with the usage of neuropsychological tools are mainly focused to Computer

Science, but are also tackling number of other research areas. Appendix A provides the list of 10 most cited papers indicating their research area.

Among 89 papers, 65% were published in conference proceedings, 34% in peer-reviewed journals, and 1 as a book chapter. Most of the papers are published in the Springer conference series: Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics (14 papers), and ACM International Conference Proceeding Series (8 papers). Large number of publications (67 journals, book chapters and conference proceedings) published only one paper focusing to the usage of neuropsychological tools in the area of e-commerce research. Based on this findings, we conclude that the journal that would specialize in this area is not yet profiled, which is an interesting opportunity that would support the development of this type of research.

Table 2: Publication years, publication source and research areas

Year	# of papers	Research area	# of papers	Source	# of papers
2017	13	Computer Science	70	Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics*	14
2016	12	Business, Management and Accounting	20	ACM International Conference Proceeding Series	8
2015	12	Mathematics	16	Others	67
2014	14	Decision Sciences	13		
2013	11	Social Sciences	12		
2012	11	Engineering	8		
2011	7	Arts and Humanities	5		
2010	6	Psychology	5		
2009	3	Economics, Econometrics and Finance	2		
2008	1	Biochemistry, Genetics and Molecular Biology & Chemistry	2		
2007	1	Energy	1		
2006	1	Environmental Science	1		
2003	2	Materials Science	1		

Source: Authors' work

Note: \* Lecture Notes include various conferences under one publication label.

Table 3 presents the most frequent authors, authors' affiliations and authors' country which yielded two or more papers.

Only one researcher authored five papers (Lee, K.C.), while six researchers authored three papers (Auinger, A., Chae, S.W., Pu, P., Sivaji, A., Wang, Q., and Yang, S.F.). Large number of researchers authored two papers (21 researcher), which leads to the conclusion that the most represented authors investigate the field of e-commerce with the usage of neurophysiological tools mostly sporadically, and that it is rarely the main focus of the research of a particular author.

Table 3 also presents the distribution of papers by authors' affiliations and authors' countries. The Republic of China, United States, South Korea, United Kingdom, Canada, Hong Kong, and were the top seven countries publishing e-commerce papers using neurophysiological tools. Countries with four publications are: Taiwan, Germany, and India, while the countries with three publications are: Japan, Malaysia, Singapore, and Thailand.

The distribution of publications according the authors' affiliations reveal that the top three institutions are: Sungkyunkwan University, Zhejiang University, and Ecole Polytechnique Federale de Lausanne. Publications with three publications are: National Sun Yat-Sen University Taiwan, National University of Singapore, UCL, Chulalongkorn University, and McMaster University.

Table 3: The most frequent authors, authors' affiliations and authors' country (≥2)

Authors	# of papers	Authors' affiliations	# of authors	Authors' countries	# of authors
Lee, K.C.	5	Sungkyunkwan University	5	The Republic of China	16
Auinger, A.	3	Zhejiang University	4	United States	9
Chae, S.W.	3	Ecole Polytechnique Federale de Lausanne	4	South Korea	7
Pu, P.	3	National Sun Yat-Sen University Taiwan	3	United Kingdom	7
Sivaji, A.	3	National University of Singapore	3	Canada	6
Wang, Q.	3	UCL	3	Hong Kong	6
Yang, S.F.	3	Chulalongkorn University	3	Switzerland	6
Castagnos, S.	2	McMaster University	3	Austria	5
Chen, L.	2	National Information Society Agency	2	Taiwan	4
Courtemanche, F.	2	NIPA	2	Germany	4
Cyr, D.	2	Fachhochschule Oberosterreich	2	India	4
Dufresne, A.	2	Universiti Teknologi Petronas	2	Japan	3
Head, M.	2	University of Zilina	2	Malaysia	3
Holzinger, A.	2	Hong Kong University of Science and Technology	2	Singapore	3
Hsieh, A.Y.	2	Universite de Montreal	2	Thailand	3
Jankowski, J.	2	Chinese Culture University Taiwan	2	Norway	2
Lo, S.K.	2	Beihang University	2	Poland	2
Ma, Q.	2	Hong Kong Baptist University	2	Slovakia	2
Rattanawicha, P.	2	Simon Fraser University	2		
Riedl, R.	2	Johannes Kepler Universitat Linz	2		
Riegelsberger, J.	2	Universitat Basel	2		
Sasse, M.A.	2	Northeastern University China	2		
Seo, Y.W.	2	Bentley University	2		
Soo, S.T.	2	West Pomeranian University of Technology	2		
Teo, H.H.	2				
Wątróbski, J.	2				
Zhang, Z.	2				
Ziemba, P.	2				

Source: Authors' work

## Usage of Neurophysiological Tools in E-Commerce

Two major groups of neurophysiological tools are used in neuroIS research [7]: (i) psychophysiological tools (eye tracking, skin conductance response, facial electromyography, and electrocardiogram), and (ii) brain imaging tools (functional magnetic resonance imaging, positron emission tomography, electroencephalography, and magnetoencephalography).

Psychophysiological tools track the respondent's actions and thoughts based on the respondent eye activity (eye pupil location (*gaze*) and movement measured by eye tracking), skin activity (sweat in eccrine glands of the palms or feet measured by skin conductance response), face activity (electrical impulses caused by muscle fibres, measured by facial electromyography), or heart activity (electrical activity of the heart on the skin measured by EEG). Brain imaging tools aim at tracking the respondent's actions and thoughts reflected in the brain, by measuring the different manifestations of brain activity, e.g. functional magnetic resonance imaging is measuring the neural activity by changes in blood flow.

Identified 89 e-commerce papers that describe the usage of neurophysiological tools were classified according to the tools used. Table 4 presents the number of papers among identified 89 e-commerce papers that describe the usage of neurophysiological tools. Research revealed that the largest number of papers described the usage of eye tracking (78 papers; 87.6%), followed by the electrocardiogram (8 papers; 9%). Other tools usage is described only in few papers (skin conductance response - 2 papers, functional magnetic resonance imaging - 3 papers). Other tools are not described to be used in e-commerce research (facial electromyography, positron emission tomography, and magnetoencephalography).

Table 4: Usage of neurophysiological tools in e-commerce papers (n=89 papers)

Neurophysiological Tools	Focus of Measurement	# of papers	% (n=89)
<b>Psychophysiological Tools</b>			
Eye Tracking	Eye pupil location (gaze) and movement	78*	87.6%
Skin Conductance Response (SCR)	Sweat in eccrine glands of the palms or feet	2*	2.2%
Facial Electromyography (fEMG)	Electrical impulses caused by muscle fibres	0	0
Electrocardiogram (EKG)	Electrical activity of the heart on the skin	0	0
<b>Brain Imaging Tools</b>			
Functional Magnetic Resonance Imaging (fMRI)	Neural activity by changes in blood flow	3	3.4%
Positron Emission Tomography (PET)	Metabolic activity by radioactive isotopes	0	0
Electroencephalography (EEG)	Electrical brain activity on the scalp	8	9.0%
Magnetoencephalography (MEG)	Changes in magnetic fields by brain activity	0	0

Source: Authors' work, based on Dimoka et al. (2012).

Note: \*One paper is using both eye-tracking and skin conductance response analysis

## Psychophysiological Tools in E-Commerce Research

In this part of the paper the utilization of the most used psychophysiological tools in e-commerce research is presented: eye tracking, and skin conductance response.

### Eye Tracking

Papers investigating e-commerce in most of the cases used eye tracking. These tools measure the eyes position (where the respondent is looking) and eyes movement (the eye's movement in relation to the head), and collected data track the length of focus of respondent's eyes on certain place on the image (e.g. computer or mobile phone screen) or stimulus [6], [14]. The reading of the papers revealed that there are 78 papers that use eye tracking as a methodology for researching e-commerce. Detailed analysis of the research papers is not the goal of this editorial. However, in order to investigate what are the topics of the e-commerce papers that use eye tracking tools for researching to topic of interest, we used the phrase extraction process combined with the cluster analysis conducted by Wordstat Provalis software. Table 5 presents phrases with more than 2 words with the frequency of occurrence  $\geq 5$ , and figure 1 presents the results of the cluster analysis that identified 7 groups of topics in e-commerce, using Jaccard's coefficients, that are analysed with the eye tracking: (i) visual attention of human brands; (ii) image appeal of human images; (iii) decision quality generated by the usage of recommender systems; (iv) product image used in human-computer interactions measured by the fixation count and fixation duration; (v) purchase intentions measured by the high and low elaborations as well as peripheral cues; (vi) impacts of banner ads on brand awareness and (vi) viewing behaviour in relation to user experience. Examples of research related to the topics are as the following as provided in respective order [9], [10], [11], [12], [13], [18].

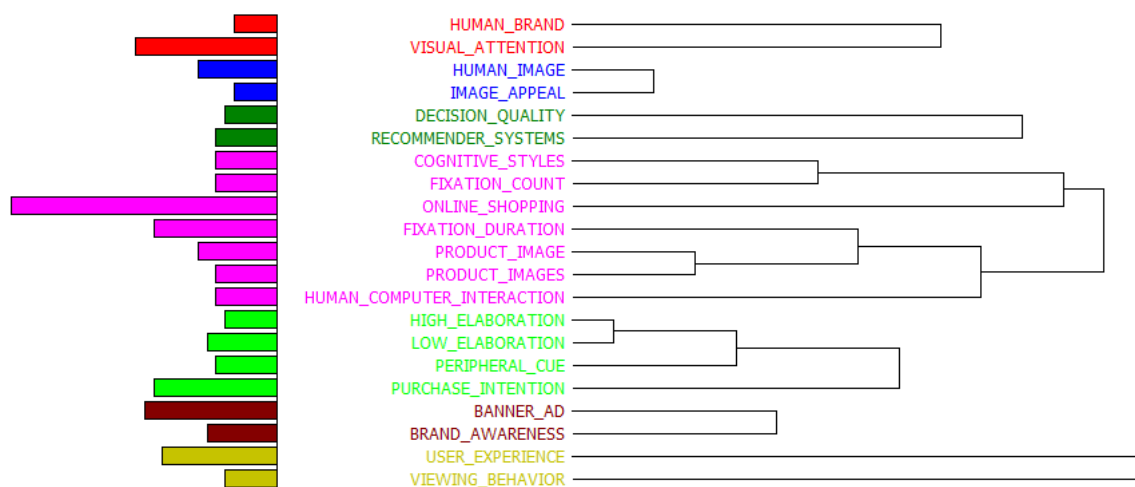


Figure 1: Cluster analysis of phrases in abstracts of papers using eye tracking for the investigation of e-commerce topics of research

Table 5: Phrases of e-commerce papers using eye tracking (≥ 5 occurrences)

	# of occurrences	# of papers	% of papers
Online shopping	35	21	26.92%
Visual attention	16	9	11.54%
Banner ad	15	2	2.56%
Fixation duration	14	8	10.26%
Purchase intention	14	6	7.69%
User experience	13	10	12.82%
Image appeal	10	3	3.85%
Human brand	10	2	2.56%
Product image	9	3	3.85%
Human image	9	2	2.56%
Historical sales	9	1	1.28%
Low elaboration	8	2	2.56%
Brand awareness	8	2	2.56%
Human computer interaction	7	5	6.41%
Fixation count	7	5	6.41%
Recommender systems	7	4	5.13%
Cognitive styles	7	3	3.85%
Product images	7	2	2.56%
Attentional resources	7	1	1.28%
Peripheral cue	7	1	1.28%
Decision quality	6	2	2.56%
High elaboration	6	2	2.56%
Viewing behavior	6	2	2.56%
Usability evaluation	5	4	5.13%
Website design	5	4	5.13%
Trust building	5	2	2.56%
Banner ad fixation	5	1	1.28%
Brand image appeal	5	1	1.28%
Banner ad position	5	1	1.28%
Human preference	5	1	1.28%
Product knowledge	5	1	1.28%
Product pictures	5	1	1.28%

Source: Authors' work, using Provalis Wordstat software

Figure 2 presents the proximity plot indicating which phrases occur the most often with the phrase online shopping, which is the most frequent phrase. The phrases that occur are related to the eye movement, such as visual attention, fixation count and duration, high and low elaboration and viewing behaviour. However, other phrases that occur indicate the particular topics of the research, such as purchase intention, brand awareness, decision quality, human brands and images, image appeal, product images, website design and user experience.

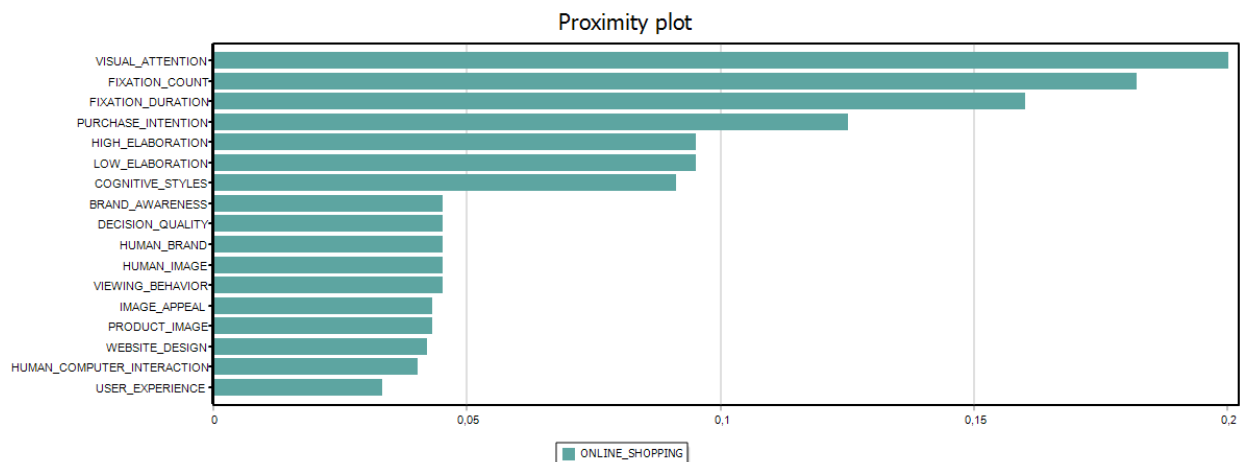


Figure 2: Proximity plot of the phrase occurring the most often with the phrase online shopping

## Skin Conductance Response

Only two papers used the skin conductance response, and one of them in combination with eye tracking. Example of the research using skin conductance in e-commerce is its usage 'as proxies for the immediate emotions and overall arousal of human bidders in a lab experiment with human and computerized counterparts' [15].

## Brain imaging Tools in E-Commerce Research

In this part of the paper the utilization of the most used brain imaging tools in e-commerce research is presented: functional magnetic resonance imaging and electroencephalography.

### Functional Magnetic Resonance Imaging (fMRI)

When neural activity occurs in a brain, it generates a stronger change in blood flow than in oxygen metabolism, which causes the blood to be more oxygenated in case of increased neural activity. This effect is called blood oxygenation level dependent (BOLD) effect, and is used as a basis for fMRI, which has excellent spatial resolution, which precisely measures the location of the event in the brain, while the temporal resolution is weak, due to the length of the BOLD effect. Example of the research using fMRI 'is introduced to capture consumer's neural activities in the region of interest (ROI) related to metacognition across the conditions of e-commerce websites with and without EPCs in a manipulated online shopping scenario' [19].

### Electroencephalography (EEG)

EEG quantifies the 'electrical brain activity from extracellular ionic currents that are caused by dendritic activity' [8]. It has excellent temporal resolution measured in milliseconds, but spatial resolution is poor. Example of the usage of EEG in e-commerce research the measurement of the response of participants to social commerce and e-commerce reviews, where social commerce reviews were from friends, and e-commerce reviews from strangers. By the usage of EEG, it was revealed that participants paid more consideration to the social commerce reviews compared to e-commerce reviews [3].

## Conclusion

Neurophysiological tools have attracted significant attention in diverse areas of social science research. Its usage in the area of information systems has become widespread, and broader description of the neurophysiological tools with the information of their pricing is provided by Dimoka et al. [7]. The goal of this editorial is to incite the readers of Journal of Theoretical and Applied Electronic Commerce Research to consider the usage of neurophysiological tools in their research. With this goal in mind, the systematic search of Scopus database was conducted in order to detect the papers that report the usage of neurophysiological tools as a methodological tool for researching topics related to e-commerce. Bibliographical analysis revealed that the publication of studies reporting the usage of neurophysiological tools in e-commerce research is increasing, but it is dispersed across various journals and conference proceedings. Analysis revealed 89 papers, that use in most of the cases eye-tracking methodology to investigate different topics, such as image appeal of human images and impacts of banner ads on brand awareness, while other tools are used only in few papers. Other neurophysiological tools were used to much lower extent. Possible reason of the popularity of eye tracking is due to its price affordability and measurement of eye activity, which is tightly related to e-commerce that is conducted over web and mobile sites.

This overview of the usage of neurophysiological tools in e-commerce research leaves number of questions unanswered. Only a few of them will be mentioned here. What are the benefits of neurophysiological tools in combination and, in comparison with behavioural research, such as survey self-reporting studies and web mining behavioural data, taking into account effort and price of the research? What are the possible pitfalls in conducting the e-commerce research using neurophysiological tools, and how to avoid them? Which topics of e-commerce are already investigated with high-quality research using neurophysiological tools, and which topics are emerging as important?

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## Appendix A: The Most Cited Papers (≥10 citations)

	Main research area	# of citations	Filed Weight Citation Impact*	Scopus Percentile in Main Research Area*
Cyr, D., Head, M., Larios, H., & Pan, B. (2009). Exploring human images in website design: a multi-method approach. <i>MIS quarterly</i> , 539-566	Computer sciences	209	7,83	99%
Wang, Q., Yang, S., Liu, M., Cao, Z., & Ma, Q. (2014). An eye-tracking study of website complexity from cognitive load perspective. <i>Decision support systems</i> , 62, 1-10.	Arts and Humanities	30	4,24	97%
Sivaji, A., Downe, A. G., Mazlan, M. F., Soo, S. T., & Abdullah, A. (2011). Importance of incorporating fundamental usability with social & trust elements for e-commerce website. In <i>Business, Engineering and Industrial Applications (ICBEIA), 2011 International Conference on</i> (pp. 221-226). IEEE.	Business, Management and Accounting	21	11,43	98%
Huang, Y. F., & Kuo, F. Y. (2012). How impulsivity affects consumer decision-making in e-commerce. <i>Electronic Commerce Research and Applications</i> , 11(6), 582-590.	Business, Management and Accounting	19	1,32	84%
Castagnos, S., Jones, N., & Pu, P. (2010, September). Eye-tracking product recommenders' usage. In <i>Proceedings of the fourth ACM conference on Recommender systems</i> (pp. 29-36). ACM.	Engineering	19	3,86	96%
Goh, K. N., Chen, Y. Y., Lai, F. W., Daud, S. C., Sivaji, A., & Soo, S. T. (2013, April). A comparison of usability testing methods for an e-commerce website: A case study on a Malaysia online gift shop. In <i>Information Technology: New Generations (ITNG), 2013 Tenth International Conference on</i> (pp. 143-150). IEEE.	Computer sciences	17	7,08	97%
Wook Chae, S., & Chang Lee, K. (2013). Exploring the effect of the human brand on consumers' decision quality in online shopping: An eye-tracking approach. <i>Online Information Review</i> , 37(1), 83-100.	Engineering	14	1,58	70%
Schmutz, P., Roth, S. P., Seckler, M., & Opwis, K. (2010). Designing product listing pages-Effects on sales and users' cognitive workload. <i>International journal of human-computer studies</i> , 68(7), 423-431.	Engineering	10	1,03	55%

Source: Author's work based on citation analysis

Note: \* Corrected for the year of publication, document type and main research area; Field-Weighted Citation Impact greater than 1 indicates that the paper is cited more than expected in average