Affective – Cognitive – Usability (ACU) Model Incorporating Eye Tracking Analysis for Redesigning the e-Commerce Website

Markus Hartono(✉), Argo Hadi Kusumo, and Dwilita Aprilin Asikin

Department of Industrial Engineering, University of Surabaya, Surabaya, Indonesia
markus@staff.ubaya.ac.id

Abstract. This study discusses the investigation of how both cognitive and affective factors bring significant impact on the usability in e-commerce website selling consumer products. It raises a question of which one is more dominant, whether it is cognition or affect for consumer experience? It is a critical thing to investigate. Eye tracking analysis is utilized to emphasize concerns related to comfortable display. A case study on a popular e-commerce website of consumer products in Indonesia was taken to validate the proposed model. Through Structural Equation Modeling (SEM), it shows that affect was found to be more dominant than that of cognition in affecting to usability. In order to provide more applicable improvement strategy related to efficiency of display, eye tracking analysis was used. The analysis referred to metrics that have been designed in the research of Ehmke and Wilson [1] which focuses on the number of fixations and revisits in the Area of Interest (AOI). The most critical proposed improvement was that to change the location of the product price ordering menus so that they are adjacent to where the search results filter elements are located in that e-commerce website. Practical and theoretical implications were discussed as well.

Keywords: Affective · Cognitive · Usability · e-Commerce website · Kansei

1 Introduction

1.1 Background and Research Motivation

Both cognitive and affective process have been taken into account for both product and service interaction. It leads to the usability of product and service. Not only cognitive based, the product and service usability also consider the affect or emotional needs of customer. The cognitive aspect of usability is shown through ease of use, identification, download delay and trust, whereas the affective one is through colors, images, shapes, and perception of information system. Hence, a unified cognition and affect provides a comprehensive human information and processing system which leads to any forms of customer intention as a consequence.

Cognition alone is insufficient in representing a whole experience of customer interaction with product and services. Affect will complement this human-system interaction.

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As a result, both affective and cognitive evaluation will bring more complete information for product and service development. According to Khalid and Helander [2], affect or Kansei will make judgement faster than cognition. For instance, affect will be responsible for assessing whether the environment is safe or dangerous. Cognition is quite related to formulation of meaning and beliefs due to perceived information.

As discussed earlier, usability is positioned to be a consequence due to complex process of cognition and affect in service or product interaction. A recent study by Prastawa et al. [3] tried to build a comprehensive model of affective process, cognitive process, and usability taking into account e-learning as the empirical study involving undergraduate students as respondent. However, the opportunities for conducting this study are still prospective. Limitations on the diverse of service settings and also the number of respondents motivate this current study. Hence, it is still quite interesting to explore more the interaction of affective-cognitive-usability (known as ACU model) incorporating different service settings as a way to investigate the generalization of the proposed model.

1.2 Problem Statement

Studies on the relationship between affective, cognitive, and usability (ACU) is still relatively rare. Recent study by Hartono and Raharjo [4] shows that affect (as represented by Kansei) and cognition have proportional weight on customer loyalty. Cognition here is represented by overall satisfaction due to rational assessment of perceived service quality. More specifically, Kansei and cognition account for 24% and 28%, respectively.

E-commerce website is a vital feature of online business information platforms, and it is full of complex customer mental process experience. Study by Prastawa et al. [3] shows that cognition is still found to be the primary determinant of usability. Once it is replicated to other product experience or service settings, the results could be different. Nevertheless, a study on ACU model in services is very potential to explore. Which one is more dominant whether cognitive or affective process in influencing the usability performance, is deemed to be quite interesting. It is especially for product or service designer in tackling issues on which product or service attributes are critical to customer.

1.3 Objective and Question

This study has two main objectives as follow. First, it is to examine and analyze the relationship among the constructs of affect, cognition, and usability (ACU) for e-commerce website of consumer products incorporating eye tracking analysis. A modified model of ACU (i.e., modification from [3] and an empirical study on a very popular e-commerce website in Indonesia) are reported. The second is that to formulate the improvement strategies for e-commerce website services based on the findings of path model above. Study on the investigation of e-commerce service attributes or components is interesting nowadays, especially in the pandemic since many people are involved in Work-from-Home (WfH) activities. It is so obvious the use of internet or online platform including e-commerce transaction is very intensive.

2 Methodology

This study applied survey interview and face-to-face questionnaire as a powerful research method in exploring framework [5] and proven effective [6, 7]. Convenience sampling was used. Adopting the previous A-C-U framework [3], there were 3 hypotheses:

H1: Cognition has positive impact on Affect at the e-commerce website transaction
H2: Affect has positive impact on Usability at the e-commerce website transaction
H3: Cognition has positive impact on Usability at the e-commerce website transaction

The respondents aged 19–24 years old with number of 56 subjects and were deemed sufficient for the Structural Equation Model Partial Least Square (SEM-PLS) [8] and with minimum of 39 sample [9]. The rationale is as follows. This is obtained from the average range of the number of samples needed to perform the analysis using the Structural Equation Model Partial Least Square (SEM-PLS) based on previous research. Based on previous research conducted by the Nielsen Norman Group, the minimum number of respondents in an eye tracking study in order to get stable results is 39 people. Thus, the determination of the number of samples of 56 people is deemed correct in conducting this research. This has also taken into account the possibility of failure in the recording of respondents in collecting eye tracking data.

The user being researched was given a task to do when the user accesses the e-commerce website which can be called a task. This task represents the core activity of e-commerce. The task is designed to create uniformity for all respondents who are tested using either the questionnaire method or eye tracking. The results of the questionnaire in the form of a Likert scale were analysed using the Structural Equation Model Partial Least Square (SEM-PLS) with the help of SmartPLS software. The results of data processing using the SmartPLS software answered the designed hypotheses.

3 Results

Using the SEM-PLS, the validity and reliability tests for the survey instrument were done. Through several iterations, the final path model was set, valid and reliable. It is shown in Fig. 1. The Goodness of Fit (GoF) of 0.8594 showed that the cognition and affect can explain 85.94% of the usability. All t-statistics values at all alternative hypotheses were greater than the significant value at the alpha of 5% (i.e., 1.96). The relationship between X1 and X2 is 10.59; between X1 to Y is 3.97; and between X2 to Y is 4.42, where these three values were greater than 1.96. This means reject H0. Thus, based on these results it can be concluded that the cognitive and affective aspects had a significant effect on user usability in using the e-commerce website.

Hence, both cognition and affect had a significant effect on the usability. It shows that affect was more dominant than cognition in affecting usability. In other words, in a case of e-commerce, affect was more important than that of cognition.

Through quadrant analysis, subjected to user perception and factor loading of structural model, there were two critical attributes, i.e., (i) The user is aware of any errors occurred, and (ii) The user can cancel any orders made. In formulating improvement

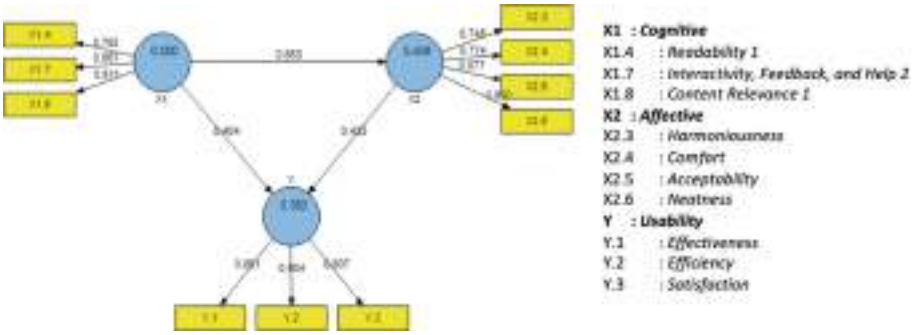

Fig. 1. A significant structural model Affective-Cognitive-Usability (ACU) in e-commerce website

strategy, eye tracking analysis was used according to the number of fixations and revisits in the Area of Interest (AOI). Both are related to error prevention.

4 Discussion

According to the findings of path model and hypotheses testing, cognition was proven significantly as the antecedent of affect. This confirms the previous study by Hartono and Tan [6]. Comparing the effect on usability, the affect construct was more dominant than that of the cognition. It was shown by the path coefficient of affect (0.433) which was higher than that of the cognition (0.404) on usability. It was unique and interesting since the respondents' rationale and feeling was proportional when it came to the case of e-commerce website.

More specifically, in the usability attribute "Efficiency – I can achieve my goals quickly and economically when using the e-commerce website" was critical. Indeed, both rationale and emotion were merged and equally important when it was dealing with e-commerce website experience. Afterward, through eye tracking, the details of problem related to fixations and revisits on area of interest (AOI) and how to solve it were formulized. The average fixations and revisits were deemed to be sufficient input for improvement. An example of AOI for a certain task related to variable "error prevention" is provided in Fig. 2.

The error prevention issue was becoming the prominent concern. Some proposed improvement strategies were as follow. First, to change the location of the product price ordering elements so that they are adjacent to where the search results filter elements are located. Second, to provide a list entry containing words that are close to the keyword when the user types the keyword in the search box. Third, to provide word suggestions in the error description in the form of correcting keywords that can be clicked directly to go to the search for that word. Fourth, to remove the "Other" element and position the order cancellation element which can be directly selected in the order list view. One example of a comparison between the existing and proposed condition is shown in Fig. 3.

This study has limitations at the relatively small sample size, service setting, and previous research studies on the similar topic.

Fig. 2. AOI for task related to error prevention

Fig. 3. A comparison between the existing condition and proposed design related to change of ordering and filtering product

5 Conclusion

This study has proposed and validated the model of affect, cognition, and usability (ACU) by taking into account an empirical study on e-commerce website of a popular business in Indonesia. It is hoped that the e-commerce service provider may use this study as a practical guidance for making their business more effectively and efficiently.

This research is expected to be useful for e-commerce companies and academics. For e-commerce companies, this study provides an illustration that the usability aspect of an e-commerce website is also part of the quality of the website, so it is important to pay attention to the website's performance in accordance with customer expectations as a user. The results of this study are also expected to provide guidelines or references for designers and developers of e-commerce websites in designing, developing and improving website designs so that they meet the usability aspect by paying attention to the cognitive and affective aspects. For the academic community, this research is expected to provide a reference on usability testing by considering cognitive and affective aspects which refer to the indicators of the Affective-Cognitive-Usability integration model through questionnaire instruments and eye tracking methods.

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Université de Moncton
Moncton, NB, Canada

Ian Noy
Toronto, ON, Canada

W. Patrick Neumann
Department of Mechanical and Industrial Engineering
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Toronto, ON, Canada

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Preface

The International Ergonomics Association (IEA) is the organization that unites Human Factors and Ergonomics (HF/E) associations around the world. The mission of the IEA is "to elaborate and advance ergonomics science and practice, and to expand its scope of application and contribution to society to improve the quality of life, working closely with its constituent societies and related international organizations" (IEA, 2021). The IEA hosts a world congress every three years creating the single most important opportunity to exchange knowledge and ideas in the discipline with practitioners and researchers from across the planet. Like other IEA congresses, IEA2021 included an exciting range of research and professional practice cases in the broadest range of Human Factors and Ergonomics (HF/E) applications imaginable. While the conference was not able to host an in-person meeting in Vancouver, Canada, as planned by the host Association of Canadian Ergonomists/*Association canadienne d'ergonomie*, it still featured over 875 presentations and special events with the latest research and most innovative thinkers. For this congress, authors could prepare a chapter for publication, and 60% chose to do so. The breadth and quality of the work available at IEA2021 are second to none—and the research of all authors who prepared their publication for this congress is made available through the five volumes of these proceedings.

The International Ergonomics Association defines Human Factors and Ergonomics (HF/E) synonymously as being:

> *the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.*
>
> *Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people.*
>
> *Ergonomics helps harmonize things that interact with people in terms of people's needs, abilities and limitations.* (https://iea.cc/definition-and-domains-of-ergonomics/)

The breadth of issues and disciplines suggested by this definition gives one pause for thought: what aspect in our lives is not in some way affected by the design and application of HF/E? For designers and managers around the world, a similar realization is growing: every decision made in the design and application of technology has implications for the humans that will interact with that system across its lifecycle. While this can be daunting, the researchers and professionals who participated in IEA2021 understand that, by working together across our disciplines and roles, we can achieve these lofty ambitions. This is especially relevant as we continue our collective journey into an increasingly "interconnected world"—the theme for the 21st IEA Congress. With the rise of a myriad of technologies as promulgated by Industry 4.0 proponents, we need now, more than ever, the skills and knowledge of HF/E researchers and practitioners to ensure that these tools are applied in a human-centric way towards resilient and sustainable systems that provide an enduring and sustainable road to prosperity—as advocated in the new Industry 5.0 Paradigm (Breque et al. 2021). Where the trend of Industry 4.0 aims primarily at encouraging technology purchasing and application, Industry 5.0 includes goals of resiliency and sustainability for both humans and our planet. These proceedings provide examples of research and development projects that illustrate how this brighter, human-centred future can be pursued through "*Ergonomie 4.0*", as stated in the French theme of the Congress.

While the theme of the Congress concerns human interactions within a rapidly evolving cyber-physical world, the devastating impact of the COVID-19 pandemic has given an added dimension to the Congress theme and its delivery model. As the pandemic began to engulf the world, the traditional in-person Congress became increasingly less viable and gave way to the creation of a hybrid model as a means to enhance international participation. In early 2021, it became clear that holding an in-person event would not be possible; hence, the Congress was converted to a fully virtual event. The uncertainty, mounting challenges and turbulent progression actually created new possibilities to engage the global HF/E community in ways that were never previously explored by the IEA. Indeed, one of the scientific tracks of the congress focuses explicitly on HF/E contributions to cope with COVID-19, and readers will find some submissions to other tracks similarly focus on what HF/E practitioners and researchers bring to the world during this pandemic period. This journey epitomizes broader transformative patterns now underway in society at large and accentuates the urgency for resilience, sustainability, and healthy workplaces. No doubt, the notion of globalization will be redefined in the wake of the pandemic and will have far-reaching implications for the connected world and for future society, and with new paradigms emerge a host of new human factors challenges. The breadth of topics and issues addressed in the proceedings suggests that the HF/E community is already mobilizing and rising to these emerging challenges in this, our connected world.

IEA2021 proceedings includes papers from 31 scientific tracks and includes participants from 74 countries across 5 continents. The proceedings of the 21st triennial congress of the IEA—IEA2021—exemplify the diversity of HF/E, and of the association, in terms of geography, disciplines represented, application

domains, and aspects of human life cycle and capability being considered. Our diversity mirrors the diversity of humans generally and is a strength as we learn to weave our knowledge, methods, and ideas together to create a more resilient and stronger approach to design than is achievable individually. This is the strength of the IEA congresses, in the past, in the current pandemic-affected 21st occasion, and in the future. There is no other meeting like it.

A substantial number of works were submitted for publication across the Scientific Tracks at IEA2021. This gave us the happy opportunity to group contents by common threads. Each volume presents contents in sections with papers within the track's section presented in alphabetical order by the first author's last name. These proceedings are divided into five volumes as follows:

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Richard Gardner	Boeing Research & Technology, USA

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Maggie Graf	International Ergonomics Association - Professional Standards and Education, Certification Sub-committee, Switzerland
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Andrew Thatcher	University of the Witwatersrand, South Africa
Giulio Toccafondi	Center for Clinical Risk Management and Patient Safety GRC, WHO Collaborating Center, Florence, Italy

Andrew Todd	Rhodes University, South Africa
Judy Village	University of British Columbia, Canada
Christian Voirol	University of Applied Sciences Western Switzerland, University of Montreal, Switzerland
Michael Wichtl	AUVA-Hauptstelle, Austrian Ergonomics Society, Austria
Amanda Widdowson	Chartered Institute of Ergonomics and Human Factors (CIEHF), Thales, UK
Sascha Wischniewski	Federal Institute for Occupational Safety & Health (BAuA), Germany

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