

Advances in Intelligent Systems and Computing 1298

Alma Maria Jennifer Gutierrez
Ravindra S. Goonetilleke
Rex Aurelius C. Robielos *Editors*

Convergence of Ergonomics and Design

Proceedings of ACED SEANES 2020

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Preface

Background

The Human Factors and Ergonomics Society of the Philippines (HFESP) is an organization dedicated to promoting the professional practice of human factors and ergonomics in the Philippines. The organization’s mission is to strengthen education and training in the field of ergonomics and to promote partnership among organizations with interest in ergonomics and human factors. HFESP together with De La Salle University will host the **Joint Conference on Asian Council and Ergonomics and Design (ACED) and South East Asian Network of Ergonomics Societies (SEANES) 2020**. This is the first time that these two conferences will come together. The resulting conference is endorsed by the International Ergonomics Association (IEA).

The Asian Council of Ergonomics and Design (ACED) is an organization composed of 11 ergonomics societies in Asia. Its vision is to take an Asian initiative in ergonomics and design. The council aims to reflect fast changing needs and issues of Asian academics and industries, enhance collaboration and relationship among Asian scholars and practitioners, disseminate Asian ergonomic standards and regulations to the rest of the world, and enhance the contribution of Asian professionals in the international societies. The first ACED conference was held in Jeju, Korea, in May 2014 and is held every three years.

The South East Asian Network of Ergonomics Societies (SEANES) is a federation of human factors and ergonomics societies in South East Asia (SEA). It is a voluntary and nonprofit entity with five ergonomics societies as members. The first SEANES conference was held in Cebu, Philippines, in 13 December 2010. Dr. Andrew Imada, the IEA President, presided at the inauguration of SEANES. This conference was held every two years and the last conference was in Bangkok, Thailand.

The theme of this year’s conference is “Convergence-Creating Ergonomic Breakthroughs thru Partnership.” In this information-driven and consumption-driven world, the field of ergonomics has a significant role to play in

issues such as sustainability, data analytics, innovation, and health promotion among others. These issues can effectively be addressed through effective cooperation of ergonomists from other disciplines. Innovative technologies flourish because of the unique contribution of each team member at each stage of the problem-solving process.

This proceedings of the Joint Congress of the Asian Council of Ergonomics and Design and the Southeast Asian Network of Ergonomics Societies wants to espouse the researches and current practices from all over the world that focuses on the relevant work in the area of human factors and ergonomics. This presents an opportunity to advocate and publicize the value of using ergonomics as a strategy for organizational effectiveness and efficiency.

Organization of the Proceedings

The field of human factors and ergonomics has undergone significant change over the past two decades. This proceeding offers a wide range of topics each focusing on a major area of interest for human factors and ergonomics professionals. The topics includes affective design, anthropometry, ergonomics in manufacturing, health and safety, healthcare ergonomics, human capabilities, human–computer interaction, mental workload, musculoskeletal disorders, product design, transport ergonomics, and visual ergonomics.

We would like to thank the organizing committees and all the members of the scientific committees and reviewers. They have worked tirelessly in reviewing papers and making valuable recommendations for the authors to enhance their work. We would like to thank Prof. Ravindra Goonetilleke for providing extra help in the review process and the authors for sharing their research at the conference. We would also like to thank Pierpaolo Riva of Springer for assisting us throughout this venture.

Alma Maria Jennifer Gutierrez
Ravindra Goonetilleke
Rex Robielos

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Affective Design



Building a Database of 4D Movie Clips Eliciting Affect/Emotions

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Abstract. 4D movie theaters provide a movie with various effects such as chair movements, vibrations, winds, and scents so that the audience can get more immersed in the movie. To examine affective/emotional responses of 4D movie audiences, movie clips that could elicit affective/emotional perception and empathy are needed. Although databases (DBs) of movie clips eliciting emotion have been built, they were made without considering characteristics of 4D movies. This study evaluated major discrete affect/emotions of 4D movies and made a DB of 4D movie clips eliciting affect/emotions. Based on the developed DB, this study identified the discrete affect/emotions mainly expressed in 4D movies and scenes where motion effects could be provided. The results of this study are expected to be useful for making 4D movies and conducting future affect/emotion studies.

Keywords: Affect · Emotion · Emotion elicitation · Movie clips · 4D movies · Motion effect

1 Introduction

4D movie theaters enable the audience to experience a movie with the five senses. A 4D movie usually presents various effects such as chair movements, vibrations, water sprays, air shots, and scents. The chair movements are defined as motion effects. The motion effects are the most frequently used effects in 4D movies to enhance the immersion of the audience [1]. Understanding of affect and emotions expressed by the characters and empathy for characters could influence immersion in a movie [2]. However, it is difficult to find studies that examined the affective/emotional responses of 4D movie audiences to the motion effects.

Some studies used movie clips to investigate emotional responses. Since a movie clip is an effective stimulus that elicits affect/emotions, movie clips are used to investigate emotional responses in several studies. Accordingly, the databases (DBs) of movie clips eliciting emotions have been built [3–10]. The common purposes of the existing DBs are to use for emotion studies and to validate their emotion classification algorithm.

The existing DBs, however, cannot be used for studies to investigate affect/emotions about motion effects. This is because previous studies have not focused on the movements of a camera or characters and not taken into account the movie genres.

The clip should have active movements of a camera of characters to investigate responses about motion effects. Motion effects can accompany the movements in the clip and the movements usually appear in action or science fiction (SF) genres. When collecting 4D movie clips, movie genres should be considered.

Affect and emotion are different and their types are various. Affect is the subjective feeling that a person receives from an object, such as ‘bright’ and ‘hot’. Unlike affect, emotion is the internal feeling of a person caused by external or internal factors, such as ‘happy’ and ‘sad’ [11]. The existing studies have built DBs eliciting emotion only. The movie clips were collected for a small number of emotions, ranging from 6 to 9. Although Jurášová and Spajdel [9] considered 28 emotions, there are more various types of affect/emotions. The affective/emotional responses of movie audiences can be diverse since there are various movie genres or stories and about 100 scenes in a movie. 4D movie clips for various affect/emotions should be collected to study affect/emotions of 4D movie audiences.

This study aims to select the major affect/emotions in 4D movies and to build a DB of 4D movie clips eliciting affect/emotions. To achieve the goals, various affect/emotions and characteristics of 4D movie genres were considered.

2 Selection of Major Affect/Emotions Represented in 4D Movies

This study created three evaluation criteria to select affect/emotions which are mainly expressed in 4D movies among the various affect/emotions (Table 1). The commonality of genres means the degree commonly expressed in various 4D movie genres produced. Appearance frequency refers to the frequency with the affect/emotions utilized in 4D movies. Before evaluating commonality of genres and appearance frequency, we checked the genres of 110 4DX movies released by CGV from January 2015 to September 2019 in NAVER Movie [12] and figured out the 4D movie genres. Contributions to understanding the story, another criterion, indicates how important the affect/emotions are in understanding the story. Based on three evaluation criteria, this study evaluated 109 affect/emotions on a 100-point scale (Table 1). The 109 affect/emotions are from Kang et al. [13] that collected and classified the Korean affective/emotional expressions in existing studies and Korean dictionary.

Table 1. Criteria for selecting major affect/emotions

Evaluation criteria	Description
Commonality of genres	Is the affect/emotions commonly expressed in movie genres produced in 4D movies?
Appearance frequency	How often are the affect/emotions expressed in 4D movies?
Contributions to understanding story	How important is the affect/emotions are in understanding the story?

This calculated the weight of each evaluation criterion by conducting the Analytic Hierarchy Process (AHP) to select major affect/emotions by combining the evaluation of the three criteria. The importance of affect/emotions in 4D movies was a weighted average score (Eq. (1)).

$$\begin{aligned} \text{Importance} = & 0.089 \cdot (\text{Commonality of genres}) + 0.266 \cdot (\text{Appearance frequency}) \\ & + 0.646 \cdot (\text{Contributions to understanding story}) \end{aligned} \quad (1)$$

The affect/emotions with a score of 50 or higher were selected as the major affect/emotions. Among 109 affect/emotions that were evaluated, 73 (67%) affect/emotions were selected. Of these, 21 were descriptive affect, 25 were evaluative affect, and 27 were emotion.

3 Building a Database of 4D Movie Clips Eliciting Affect/Emotions

We collected movie clips that elicit major affect/emotions. The movie clips were extracted from six movies (Table 2), which were released in 4DX at CGV in Korea in 2018 and 2019. The researchers watched these movies at the 4DX cinema.

Table 2. Six movies which clips were collected from

Movie title	Genres	# of clips collected
Avengers: Endgame	Action, adventure, SF	64
Captain Marvel	Action, adventure, SF	50
Harry Potter and the Chamber of Secrets	Action, adventure, fantasy, family	61
How to Train Your Dragon	Animation, action, adventure, SF, fantasy, family	45
How to Train Your Dragon: The Hidden World	Animation, action, adventure, SF, fantasy, family	52
Ralph Breaks the Internet	Animation, adventure, comedy, SF, family	45

We watched these six movies again in the video on demand (VOD) and gathered major movie clips eliciting affect/emotions. When collecting the clips, we determined the length of a clip so that clip contents can be easily understood.

For the collected clips, three researchers created clip title and set up start/end time. They discussed types of affect/emotions elicited by the clips and evaluated intensity of the affect/emotions. The information related to motion effects was organized to conduct a study to investigate the effect of the motion effects on the affective/emotional

responses later. Two researchers evaluated effectiveness to perceive affect/emotions for motion effects and empathy effect on motion effects.

As a result, 317 clips were collected from six movies. The average of 63.4 (s.d. 8.04) clips per movie was collected. The average number of scenes and affect/emotions per clip was 1.94 and 2.28, respectively. Forty-one affect/emotions were represented in the collected clips. Among them, there were 22 affect/emotions (Affect: 7, Emotions: 15) expressed in 10 or more clips.

Motion effects were available in most scenes expressing affect such as ‘busy’, ‘dangerous’, and ‘strong’, and emotions such as ‘surprise’, ‘worry’, and ‘fear’. On the other hand, affect/emotions such as ‘friendly’, ‘secret’, ‘love’, ‘believe’, and ‘sadness’ are often expressed in the entire clips, but rarely in scenes that could provide motion effects.

4 Discussion

This study constructed a DB of 4D movie clips eliciting affect/emotions. The previous studies built DBs only considering 6–9 emotions. In contrast, the DB developed in this study contains clips that cause 73 affect/emotions, a wider variety of affect/emotions than the previous studies. It is expected to be widely used for future affect/emotion studies.

This study identified the affect/emotions that frequently expressed in 4D movies, which can make the research process efficient and effective. It is also expected to perform experiments with the selected affective/emotional responses in a 4D movie theater.

In most movies, love between lovers or friendship is expressed. It seems that many clips expressing affect/emotions such as ‘friendly’, ‘love’, and ‘believe’ have been collected. In most genres made into 4D movies, characters fight with each other and go through many dangerous events. For these reasons, affect/emotions such as ‘busy’, ‘dangerous’, ‘strong’, ‘worry’, and ‘surprise’ were expressed frequently. When we watch the clips accompanying motion effects, affect/emotions that can be felt by big movements like fighting are often expressed. On the other hand, affect/emotions felt by small changes such as eye movements and mood are rarely expressed. This is because most motion effects are created by the movement of the characters in the video or camera movement.

The clips of the DB, however, were collected through discussion and evaluation by the researchers. In the future, the DB can be verified by recruiting participants and evaluating affect/emotions of the collected clips.

5 Conclusion

A DB of 4D movie clips eliciting major affect/emotions was constructed in consideration of the characteristics of 4D movies. The affect/emotions mainly expressed in the 4D movies were investigated. The results of this study can help researchers to induce participant's affect/emotions and select target affect/emotions in their studies.

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Role of Trust in Value Sensitive Design, Spectatorship and Identity

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Abstract. Trust or trustworthiness, as one of the personalities categories, does not belong to human exclusively. Instead, consumers could also perceive product trustworthiness, as product personality. Based on the theory of value sensitive design, spectatorship, and identity, the current study tries to answer three research questions: Why do we need to introduce trust in the design process? Is there an effect on our cognition and the consequent behavior if the trust is introduced into product design? What are the characteristics of identification - based trust in product design? By exploring the role, meaning, and insight of trust and its implication into the design, the current study tries to understand human values in a principled and comprehensive manner throughout the design process.

Keywords: Trust · Design philosophy · Value sensitive design · Spectatorship · Identity

1 Introduction

In the era of mass production, industrialization has provided excessive goods and items, lowering people's quality expectation for products. In accordance with this process, some intrinsic values, e.g. social and personal values, in product development, are ignored to some extent, such as trust in design [1]. Trust or trustworthiness, as one category of personalities, does not belong to human exclusively. Instead, consumers could also perceive product trustworthiness, as product personality. Therefore, products are symbols by which consumers convey their expectations to themselves and to others and this symbolic meaning is known to influence consumers' preference [2].

As differentiating product through technical functions becomes increasingly difficult, its symbolic meaning plays a significant role in product differentiation, evolving into product personality [3]. Although prior studies have explored some possible ways to improve product trust, systematic research on rebuilding the trust, confidence, and expectation in product design still lacks holistic theoretical investigation. Based on the theory of value sensitive design, spectatorship, and identity, the current study tries to explore the role, meaning, and insight of trust and its implication into design - understanding human values in a principled and comprehensive manner throughout the design process.

2 Role of Trustworthiness

2.1 Trust and Value Sensitive Design (VSD)

Does technology drive history or does history choose technology?

The social system of capitalism has promoted technological progress and changed the material environment of people's lives. Technology advance gradually and, eventually, develop to the degree that people do not understand, and even people do not care how a specific technology works since they unconsciously consider technology can provide the optimal solution without any modifications [4]. In other words, the social division of labor has taken the need for curiosity from the general population: people have got used to the "ignorant life". Accordingly, technology has a strong impact on people's thought and decision-making process [5]. However, within this process, less prominent values, such as social and personal value, have been compromised.

In terms of this phenomenon, Friedman, Kahn, and Borning [6] introduced value sensitive design (VSD). To be more specific, VSD is "a theoretically grounded approach to the design of technology that accounts for human values in a principled and systematic manner throughout the design process" with 12 implicated values, human welfare, ownership, privacy, freedom from bias, universal usability, trust, autonomy, informed consent, accountability, calmness, identity, and environmental sustainability.

Among these 12 concepts, trust is not a personality exclusively belonging to the human. Instead, people have a strong intention to anthropomorphized non-human with human characteristics [7]. Schneider [8] firstly adopted the terms "trust" and "trust-worthy" to describe products that performed following the expected dimensions of correctness, security, reliability, safety, and survivability. Within this term, trust, or trust in design, is associated with the condition of effective reactions between the trustors and trustees. Consequently, trust in design mainly concerns the relationship between users and their expectations.

Based on the literature mentioned above, trust in design might be defined as a sentiment of security held by the user in his/her connection with the good/product, that it depends on the recognition that the product/good is reliable and responsible for the interests and welfare of the user.

However, people nowadays have a lower intention to trust human or product and are anxious about relying on others or other goods [9]. The fundamental reason for this phenomenon might be that designer indeed focuses too much on users' needs for functionality, rather than their social and personal needs, the crucial needs for users. Concerning the cognitive nature of design [10], VSD could introduce users into the design process: designers and users co-design together so that the products/goods would be better adapted to users' true needs, rather than superficial ones, creating real values for users. Practically, VSD contained three types of investigations to make a better design work (see Fig. 1): conceptual investigations (identify, analyze and prioritize stakeholder values), empirical investigations (articulate, study and evaluate key values), and technical investigations (incorporate and analyze properties of technology

for the committed values). With the help of this framework, it would be beneficial to emphasize human value, address people’s real needs, and make a better world.

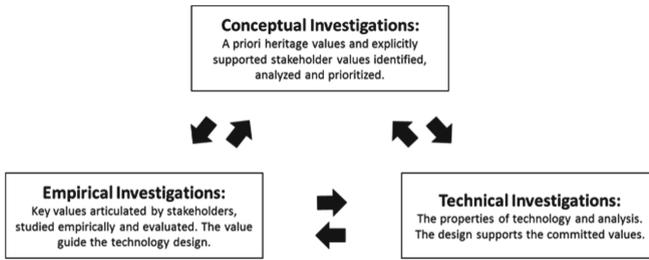


Fig. 1. Three types of investigations in VSD (Amended from [11]).

2.2 Trust, Spectatorship and Way of Seeing

Before interacting with product, human examine product in advance, which determines an active role in this relationship to product. In this case, products’ appearances and designs were adapted based on the way they would like to be treated. Along with this gradual modification, performances or appearances of products are generally “perfected” and fitted to human’s expectations, eventually “be” the human themselves, as stated by the theory of spectatorship [12].

In accordance with these intuitions stated above, this external relationship between human and product also calls for trustworthiness, especially considering the current trend of lack of trustworthiness in the society. This provides a theoretical foundation to introduce trustworthiness into this external human/non-human relationship. Regarding the particular relationship between products and human, we might ask ourselves a question:

What is the exact meaning of product trustworthiness? Is it the product we trust or distrust the same with the evaluation process towards ourselves?

In terms of human-product relationship, the existence of human is related to their control over the products while the product is only related to itself. The meaning of trust for products/goods is to the credibility that they could fulfill the needs of a human being. By anthropomorphism and empathy, the products could be believed to be “trustworthy” of its existence in the functionality they perform.

Take the most advanced technology, social robot and artificial intelligence (AI), for example. Ever since 1990s, researchers and developer of artificial intelligence and robotics tried to explore designing a special robot, which could appropriately understand, response and interact with human [13]. However, human being has shown a nuanced attitude towards social robot. On one hand, human, the handler of social robots, considered them as just one kind of “machineries”. On the other hand, along with the continuous interaction, “something” has changed. Emotional reaction or trustworthy attachment has gradually formed in the interaction. Even, we cheered with social robots when they did something good or blamed them when they failed to carry out a task [14].

On a social level, they are not just “machineries”, rather they are engaging with human as “friends”, “partners”, “listeners”, “helpers”, “solvers”, and, eventually, another “trustworthy ourselves”. In regard of this human expectation, it is not surprising that social robot generally have a human-like face [14]. Since face, as a typical human feature, could help social robot to build a recognized trust identity, fulfilling the needs of a human being. As a result, the interaction of human-robot follows a typical upward spiral: the expectation and anthropomorphism of robots drives performance and trust reliance of robots. In return, the improvement in social robots shapes the way people see and mutually reinforce expectation that constitute and extend human values [13].

The external spectatorship shapes the way we trust a product and the way we trust ourselves, helping us to get a deeper understanding of product trust. However, what might be the practical ways to improve product trust?

2.3 Identity and Trust Identification

Identity refers to a self-composed of the values that people add to the product as a signature to validate its identity. Trust could also be identified as a self-composed signature that affirms a unique product identity. As Burke and Stets [15] stated, “Trust identification refers to the process of self-identification that leads directly and indirectly, through positive emotions and trust, to the development of the committed relationship and positive emotional attachment.”

Regarding the cognitive nature of appreciating design, such identification-based trust is the highest level of trust [16]: the trustor comprehensively incorporates the characteristics of the other party and then identify it with its recognizable features. Particularly, firstly, forming cognitive model concerning its own needs, goals, and environment of reactions; secondly, activating and evaluating the relationship with characteristics of a stable feature or signature; thirdly, making a related emotional and behavioral reaction in the relationship to anthropomorphize and incorporate the goods or products as a partner.

In this way, the recognizable features work as the foundation for processing design identity and the related identification-based trust. Although trust identification and its characteristics have been long discussed, the major theme and contexts are all within the trust in a human-human relationship. Limited prior research has expanded trust research from the human-human relationship to human-product interaction. Concerning this, it would be rather interesting to adapt human characteristics of identification - based trust into design.

For example, facial identification-based trust, e.g. large round eyes, does not belong to human exclusively [18]. Instead, a product, a robot, or even artificial intelligence might also share similar identification cues to build the related identification-based trust and human robot interaction. Figure 2 shows the facial identification model proposed by Senior and Pankanti [17]. By facial identification-based trust, product identification-based trust could also involve the process of constructing, maintaining and altering a set of human shared properties or characteristics to provide the basic cues to shape their expectations and subconsciously measure the cost and benefits of their reaction. To build an identification-based trust for the product is a delicate process and requires continuous human-product interaction.

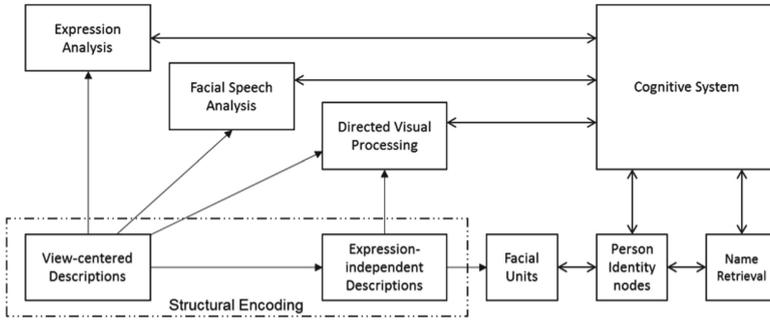


Fig. 2. Facial identification model (Amended from [17]).

3 Conclusion and Discussion

Concerning trust works as an intense bond between products and human [19], the current study tries to explore trust or trustworthiness and consider its role within the framework of value sensitive design, spectatorship and, identity (Fig. 3). Based on the theory of value sensitive design and spectatorship, the current study tries to explore human-product relationship from the internal need and external effect perspective. Value sensitive design confirmed the core role of trust in human value system while the relationship between product and product continuously shaped their external interaction: the expectation influences performance of product, in return, affected the way we saw them. Eventually, both the internal need and external effect jointly influence the practical characteristics product might have, which works as a foundation to process the identity of product. As a whole, the theory of value sensitive design, spectatorship, and identity reconsider the role of trust and contribute to the literature of ethics in product design, shedding light into the guidelines for product design.

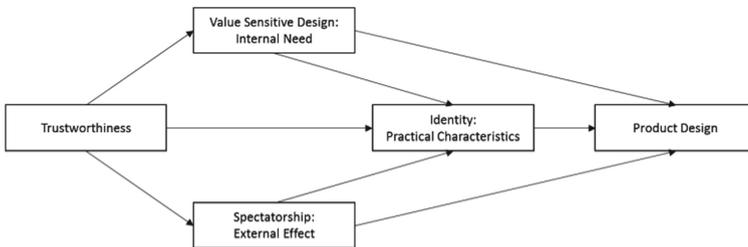


Fig. 3. The overview of the subjects chosen in the current paper

Neediness: There is a need to incorporate trust in product design since trust plays a crucial role in communicating sensitive human value. VSD introduced 12 sensitive value in human being, which is especially important for human, needs further investigation and adoption into the design process. Among those, trust might play a crucial role in the human-human relationship.

However, trust is not a cognitive activity exclusively belonging to human since people have a strong intention to anthropomorphize non-human. Considering the positive relationship between trust and human happiness, it would not be only necessary but also beneficial to incorporate trust into the design process, improving people's general well-being as a whole.

Effectiveness: Spectatorship has an effect on the way you receive and evaluate what you will see. Although we have already known that it would be necessary to adopt trust in the design process, we might be still wondering whether this idea or intuition could make a difference as expected.

Similar to human relationship, human examine product in advance, which determines an active role in this relationship to product before interacting with product. In this case, products' appearances and designs were adapted based on the way they would like to be treated. The meaning of trust for products/goods is to the credibility that they could fulfill the needs of a human being. By anthropomorphism and empathy, the products could be believed to be "trustworthy" of its existence in the functionality they perform. Thus, product trust is the extension of human trust: the external spectatorship between human and product reflects the expectation on human being themselves.

For example, in the field of social robots, the interaction of human-robot follows a typical upward spiral: the expectation and anthropomorphism of robots drives performance and trust reliance of robots. In return, the improvement in social robots shapes the way people see and mutually reinforce trust expectation that constitute and extend human value.

Characteristics: The recognizable characteristics works as the foundation for processing product identity and the related identification-based trust and human-nonhuman interaction. Though we have acknowledged that trust could be adopted into the design and have an impact on people's cognitive and behavioral action, we still lack the practical guidelines to improve trust perception in product design. According to the identification theory, the trust could also be identified as a self - composed signature that affirms a unique product identity. Consequently, the recognizable characteristics work as the foundation for processing product identity and the related identification-based trust. For instance, facial features have been long discussed in the previous cognition literature. However, limited research has ever contributed to apply this knowledge into product design, which needs further exploration and examination.

We are now in the era of artificial intelligence in which many countries have started to focus on research and application. Considering the potential significant impact on human society and technological improvement, it might not be only necessary but also crucial to pre-consider the associated ethical or moral issues, even though we are still at an initial stage [20].

Back into 1988, Levitt [21] has argued one thing to get into research on artificial intelligence is uncertainty, where human need to consider the ethical issue in advance before losing some key values, such as trustworthiness. Indeed, all the stakeholders could contribute to this issue. Based on the theories stated, designers could intentionally use product as a medium to apply internal sensitive value and external effect of

spectatorship into trust-based product design, when trying to improve trustworthiness in product as a whole.

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Estimation of Anxiety Level Using Physiological Measures for Virtual Reality Exposure Therapy System

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Abstract. Exposure therapy has problems of recurrence and patient resistance. Treatment generally begins with weak anxiety which may cause recurrence of the symptom. On the other hand, starting treatment from strong anxiety increases patient resistance. Therefore, we proposed Virtual Reality (VR) exposure therapy system that control VR contents and maintain the patient's anxiety at an appropriate level. In the previous study, we showed the possibility to estimate patients' anxiety using physiological indices. Nine healthy males participated in the experiments who were interviewed in a VR space with head mounted display (HMD). The subjective anxiety levels were rated in 11-point scoring system and physiological measures such as electrocardiogram, respiration, skin conductance (SC) were measured. Principal Component Analysis was conducted for various combinations of physiological indices. The combination of averaged heart rate (HR), low and high frequency variability of heart rate (HRVLF, HRVHF), respiratory gravity frequency (RESPGF), level and responses of SC (SCL, SCR) was chosen because of the highest explanation rate. First principal component (PC1) consists of increase in HR, HRVLF, SCL and SCR, which is interpreted as sympathetic activation and was suggested to be utilized for the estimation of anxiety level. In this study, we propose an anxiety level estimation method using the coefficients of PC1. Some degree of correlations between the estimated anxiety level and the subjective ratings were obtained for the participants who showed large changes in subjective ratings. The evaluation of this method using a large size of participants and the examination of the usefulness of the anxiety level optimization system are future issues.

Keywords: VR exposure therapy · Anxiety disorder · Physiological measures

1 Introduction

Anxiety disorder is a disease that interferes with life by feeling excessive anxiety about a particular situation in everyday life. One of the treatment methods for anxiety disorder is exposure therapy that allows a patient to experience a situation where he/she is

actually feeling anxious. It has been reported that accustomed methods starting with relatively weak anxiety may cause a recurrence of symptoms, and that starting with strong anxiety may increase the efficacy of treatment but increase the patient’s resistance to treatment [1, 2]. We made a hypothesis that the treatment that starts with weak anxiety, and maintains appropriate anxiety until the end of treatment, increases the effect and reduces patient’s resistance. In the previous study [3, 4], we propose a VR exposure therapy system that estimates the anxiety level and controls the VR content to keep it at an appropriate level (Fig. 1), and we showed the possibility to estimate the patient’s anxiety level from heart rate (HR), respiration, and finger skin conductance (SC) which can be measured without giving expressive and additional burden to patients. In the present study, we considered the relationship between patient’s subjective rating and the estimated anxiety level.

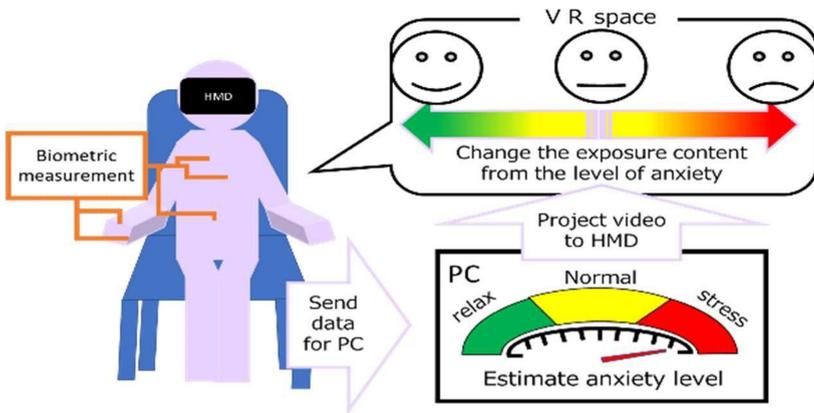


Fig. 1. Proposed system [4]

2 Preliminary Experiment

One of the authors participated in a real space experiment. We obtained physiological measures (HR, respiration, SC) during a 6-min interview in the real space (Fig. 2) and before and after the 3-min rest. The interviewer asked, “What is your name and affiliation?”, “What is your research theme?”, “Why did you choose that research item?”, “What is your plan and goal during your study in graduate school?” and responded to the participant’s reply. The participant evaluated his anxiety during the questions and answers at 11-point score system watching the video recorded after the experiment.

Figure 3 shows the temporal changes in subjective ratings at each time. Figure 4 shows the averaged value and standard deviation of respective physiological index for each session obtained in the experiment. “a” shows the data at rest before interview, “b” during interview, “c” at rest after interview. We confirmed the elevation in HR and SCL and the decrease in RESPGF during interview compared to the rest [2].

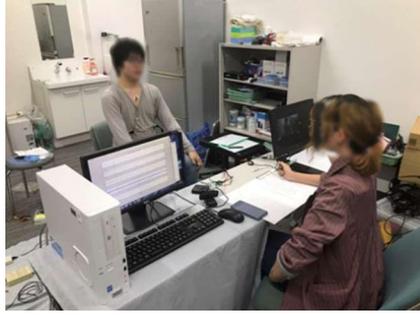


Fig. 2. A scene of the preliminary experiment

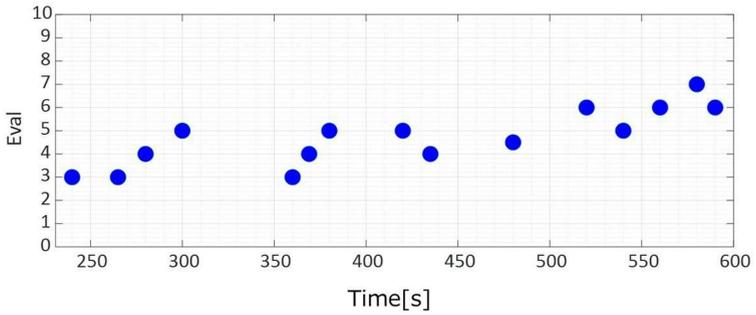


Fig. 3. Changes in subjective anxiety scores

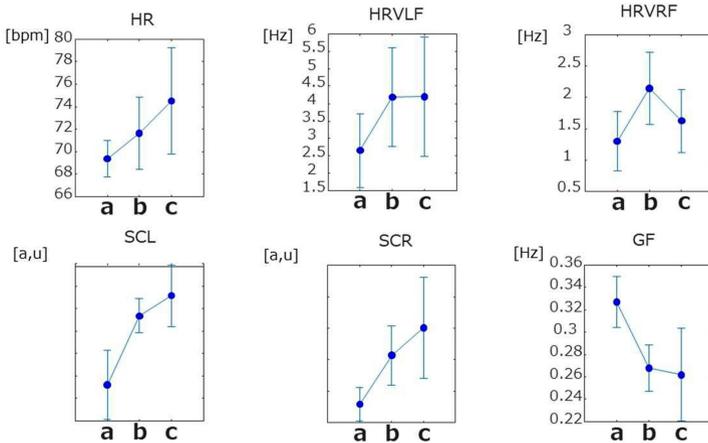


Fig. 4. Average and standard deviation of each physiological index

3 Experiment (Ethics Review, No. 2019-34)

3.1 Method

We created the interviewer’s avatar with Blender (Blender Foundation) that is 3D model and animation production software, the interview room with SketchUp2017 (Trimble Navigation Limited) that is 3D model creation software for buildings, and imported it into Unity (Unity Technologies). Four interviewers were placed in the VR space, and the experimenter controlled the reaction of them (Fig. 5). Interviewers recalls participant’s anxiety by interviewers’ attitude (looking, whispering, tilting his head) and response. Interviewers are operated by one of the authors. The interviewer asked 4 to 5 questions (Table 1). Nine healthy males (21–23 y.) who gave written consents participated in the experiment. They were required to put on a Head Mounted Display (HMD) and simulated interviews were conducted in the VR space. Participants rated their anxiety levels in 11-point scale at the end of rest and just after answering the questions. Three trials were performed for each participant.



Fig. 5. A participant with HMD (left) and a scene of virtual interview presented by HMD (right)

Table 1. Interviewer’s question

	Trial1	Trial2	Trial3
1st	What is your name and affiliation		
2nd	Please tell us about your research	What I was most devoted to when I was a student	Please tell us the news you are interested in recently
3rd	Reasons for choosing research theme	Tell us your strengths and weaknesses	What is your future dream
4th	Please tell us your goals and plans after going on to university	Is there any way to relieve stress?	What you are doing now for a dream
5th	Please tell us a story on one of your negative experiences in your life		

3.2 Analysis and Results

The average values of the physiological indices in the section without speech just before the evaluation in 20 trials from 27 trials, excluding 7 trials with measurement deficiency, were analyzed by PCA by changing the combination mainly using the indices that showed significant differences between rest and interview by t-test, and the set with the highest explanation rate was selected. The first PC consists of elevation in HR, low frequency component of HR variability, SC (both level and response) which can be interpreted as sympathetic activation (SA). The second PC consists of a decrease in respiratory component of HR variability and an increase in respiratory gravity frequency (Table 2).

Table 2. Result of PCA

	First PC consists	Second PC consists	
HR	0.47	-0.078	
HRVLF	0.33	0.40	
HRVRF	-0.18	0.68	
GF	-0.007	-0.61	
Left SCL	0.53	0.003	
Left SCR	0.60	0.038	SUM
Explanation rate (%)	33.54	23.98	57.52

We looked at the relationship between the first PC score and the second PC score at the time of rest and interview. Figure 6 is a 2-dimensional graph in which the first PC score is plotted on the horizontal axis and the second one on the vertical axis. Scores during 88 sections from all participants are shown; blue circles designate the scores during rest and red squares designate those during interview. It is shown that the first PC scores roughly are divided between scores at rest and at interview. On the other hand, large individual differences were shown in the second PC.