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Theory of Constructed Emotion Meets RE

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***Abstract*—This article proposes to employ one of the most up to date theories of emotion - the theory of constructed emotion - for engineering and validating requirements. We first provide an overview of different theories of emotion and indicate where the theory of constructed emotion lies in relation to these theories. After that, we describe possible advantages in applying theory of constructed emotion to requirements engineering. Thereafter, we postulate how the theory of constructed emotion could be applied in requirements engineering. We then hypothesize how the theory of constructed could be supported by appropriate methods and tools. Finally, we draw conclusions, and sketch the research agenda in applying the theory of constructed emotion in requirements engineering.**

***Index Terms*—Theory of constructed emotions, requirements engineering, affective computing**

I. Introduction

Rosalind Picard pioneered affective computing in 1995 as "computing that relates to, arises from, or influences emotions" [1]. This research field bridges the gap between humans and machines and especially focuses on human emotions. Affective computing has gained attention from various domains, including neuroscience, psychology, education, medicine, sociology, and computer science. In software engineering, emotions have been studied in different phases of the software lifecycle. For example, in the requirements engineering phase, emotions and sentiment analysis support the user requirements prioritization process. The study [2] analyzes the biometric data complementing the interviews to prioritize requirements for product improvement and steer the interviews based on the engagement of the users. The user feedback obtained from the app stores and Twitter has also been analyzed for the emotions or sentiments by the users expressed in textual reviews for improving the software [3], [4]. Another research direction focuses on the emotions felt by developers and shows the impact of this factor on their productivity [5], [6].

For measuring the emotional state of a person, several methods are used based on the existing psychological theories. One method is analyzing words and sentences and assigning weights to emotional words, such as love, shame, and hate. Multiple tools can be used for deducting the emotional state like SentiStrength, Stanford NLP sentiment analyzer, and NLTK. Another method is to utilize biometric data such as eye gaze, heart rate, and galvanic skin response for deducting a subject's emotional state [2], [5]. The current research also analyzes the usage of emoticons and emojis for emotional awareness and understanding. [7].

The research results presented in the exciting studies [8]–[11] have revealed that software engineers fail to give fair consideration to emotional needs by users when designing systems and considering emotional needs has not been successfully mapped to the software engineering field [12]. Therefore, with this research vision we return one step backward and propose to employ for this purpose another existing theory - the theory of constructed emotion. In this paper, we pose and partially answer the following research questions to foster the discussion and find synergies from the discussions among the research community:

- **RQ1:** What are the advantages of grounding the elicitation of emotional requirements in the theory of constructed emotion?
- **RQ2:** Where can requirements be applied that have been elicited by explicitly considering the theory of constructed emotion?
- **RQ3:** How can this theory be supported by the practical methods and tools?

II. Background

Theories of emotion can be divided into theories of basic emotion, appraisal theories of emotion, and dimensional emotion theories. According to the theories of basic emotion, there exists a set of innate discrete emotions shared among different organisms that appear to be similar and comparable across different cultures and societies [13]. Paul Ekman claims that the six basic emotions are anger, disgust, fear, happiness, sadness, and surprise [14]. In appraisal emotion theories, emotions are viewed as judgements by an individual concerning the relationships between events and the individual's environment [15]–[17]. Dimensional emotion theories declare that affective states are produced by combinations of the same elementary components [18], the most agreed ones among them being the type of valence and extent of arousal [19]. Valence and arousal determine affects, which are not emotions but much simpler feelings [20]. Valence characterises how pleasant or unpleasant one feels, while the feature of arousal is concerned with how calm or excited one feels. The immediacy of affects, and the subsequent bodily responses make them easier to be automatically detected using physiological measures, such as

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detecting excitement with a heart rate measure. Such reactions are often quantifiable after a single engagement with the technology in question, for purposes such as evaluating the effects of technostress or pleasure during online trading.

There is an increasing amount of evidence that emotions experienced by us are socially constructed in three embedded contexts: in-the-moment interactions, relationships, and cultural contexts [21]. This claim is also backed by findings in neuroscience [22]. According to the theory of constructed emotion [22], a human brain invisibly constructs everything one experiences, including emotions. Emotions are constructed in the brain, in concordance with the goals aimed to be achieved and the situations in which we are. For example, if the goal is romantic love, the emotions Passionate, Longing and Lustful might be constructed which make this goal more attainable. Differently, if the goal to be attained is tough love or brotherly love, respective instances of the emotions *disciplined and bonded* might be constructed [23]. The brain may also combine existing emotions to construct an instance of a new emotion. For example, the Japanese emotional concept of "mono no aware" stands for the despair felt at the impermanence and transience of life, especially in its most satisfying moments when our love for others, and their need for us, feels so unexpectedly overwhelming – and life so very fragile and temporary – that we become very sad [24]. This is a good example of a complex emotion that is constructed from other emotions, such as feeling love, sadness and overwhelmedness at the same time. Directly arising from this example, the advantages of the theory of constructed emotion in requirements engineering is its capability to support representation of complex emotions and real-life situations to which these emotions relate. This is very important in designing systems, such as a smart home or systems for supporting healthy lifestyles. This provides a preliminary answer to our first research question that was stated in Section I.

III. Application of Theory in RE

We will next postulate the advantages of grounding the elicitation of emotional requirements in the theory of constructed emotion.

First, when eliciting emotional requirements, we should be holistically dealing with situations rather than with discrete emotions, such as joy and anger. For example, when we are eliciting requirements for e-learning software, a virtual tutor should be embedded in particular learning situations, such as studying mathematics at home, where it should reinforce the learning process of a student by constructing relevant emotions in the student within the interactions of the learning process [25]. Moreover, an e-learning environment could even be capable of creating by means of virtual reality the simulated situations for which we learn, which include emotional experiences [26]. From e-learning we can generalize that human-computer interactions should be explicitly designed to support the creation of positive experiences in users of technology [27].

Second, emotion words have been shown to form a critical part in the emotion construction process [28]. Words have also been found to act as cues for retrieving situations from our episodic memory [29]. Moreover, psychological theories also suggest that particularly emotional words are used in our brain as cues for situations [30]. Words are also the key instruments in co-constructing emotions [31]. Considering the above findings in psychology, emotion words should be explicitly and systematically applied in the elicitation of emotional requirements. Emotion words and expressions have been organized into big corpuses, from where they can be retrieved for emotion recognition in requirements elicitation, as well as for emotion construction within human-computer interactions.

We will next outline some of the application areas where the theory of constructed emotion could be applied in requirements engineering in the first place.

One of the application areas are interactive digital narratives (IDN) [32]. A good archetypal case study of constructing situation-based emotions by IDNs is the simulation game Princess Maker2 (PM2)[1], where the player takes the role of the father who raises her daughter to the age of 18. At the end of the game, the daughter starts her working life, whereby the kind of work she does, how much talent she has for it, her marital life, and her overall happiness all depend on the actions by the player - "father". For simplicity, the events of the game take part in medieval Europe. The Princess Maker 2 provides a good example of how, among other things, emotions constructed within particular situations influence the career path and marital life of the "daughter". For example, working in the woods builds her strength and constitution, but decreases her emotional satisfaction and social reputation. On the other hand, the character will get stressed and sick, if she is working too much or is overwhelmed by social interactions. Practical usefulness of this kind of game has been well expressed by Elisa Mekler[2]: "...soon the experience reminded me of what it's like to supervise PhD students, and how academia often promotes overworking oneself and min-maxing. PM2 coincidentally taught me to pay attention to students' wellbeing and work-life balance, despite an academic system that only "rewards" productivity". Systematic elicitation and representation of requirements for IDNs of this kind should explicitly consider different life situations along with the emotions constructed by and within these situations. As another example about the elicitation of emotional requirements for IDNs, the paper [33] describes how requirements for IDNs can include colours standing for emotions. In the given case [33], the colours for emotions were obtained from two synesthetes who are more sensitive to colours compared to the mainstream population [21]. A relevant related application area is serious games, such as Aspergion described in [34], which is a multiplayer online role play game that promotes respect for people with Asperger's

[1]https://en.wikipedia.org/wiki/Princess_Maker_2
[2]Elisa Mekler, personal correspondence, 2021

syndrome. The third application area consists of applications that make use of the psychological mirror technique[3], which are rooted in emotion co-construction by the conversation partners [31]. One example of such applications is the "emotions mirror" - an affective interface that engages the user in a process of conceptualisation of their emotional state [35]. Other examples of this kind are emotionally-aware chatbots.

Emotional requirements are very important in systems and applications targeted at sensitive groups of the population, such as older adults and adolescents. Considering this, we have explicitly elicited and represented emotions to be constructed by older adults and other stakeholders in the "Pilots for Healthy and Active Ageing"[4] project, where an ecosystem of applications is developed for older adults. Using a similar method, we have explicitly elicited and represented emotional requirements for apps supporting physical activities among adolescents [36]. Such apps should explicitly consider different situations where adolescents can be, such as moving in groups, to determine the emotions that should be constructed or suppressed in situations of this kind. Likewise, considering emotions that should be constructed or suppressed among the users and other stakeholders is crucial for designing and developing robotic applications for older adults and other groups.

In healthcare applications, it also matters a lot which emotions are constructed for the stakeholders. One of such approaches [37] represents emotional requirements by a method informed by the theory of constructed emotion for two e-health applications, which have been retrieved along with the relevant functional and quality (i.e., non-functional) requirements.

This section has provided preliminary answers to the second research question that was stated in Section I.

IV. Methods and tools

We stated in Section III, based on the findings from psychology, that words are crucial in emotion construction by a human brain. Precisely for this reason, the methods of requirements engineering informed by the theory of constructed emotion should enable elicitation and representation of emotional requirements by emotion words. One of such approaches is the motivational goal modelling [11], [38], [39], which attaches word-based emotional requirements along with the quality requirements to the functional requirements as the corresponding functional goals, quality goals, and emotional goals. An advantage of this approach is a holistic representation of functional requirements, quality requirements, and emotional requirements within one hierarchical structure - goal tree. Second, elicitation of emotional requirements should be based on situations for which the requirements are elicited. Situations can be initially captured by the corresponding motivational scenarios proposed in [38], where the emotional aspects are represented by emotional descriptions of the scenarios [11]. After that, such preliminary descriptions of emotional requirements should be transformed into more fine-grained representations of situations as emotionally enriched storyboards, scenarios and process models.

In this section, we have offered a preliminary answer to the third research question that was stated in Section I.

V. Conclusions

In this paper, we first presented an overview of how theories of emotion have evolved from theories of basic emotion to appraisal and dimensional theories and finally to the theory of constructed emotion. We formulated three research questions and offered in the corresponding sections of the paper preliminary answers to these questions. Based on the answers provided, we can draw for this paper the following conclusions:

- The advantages of grounding the elicitation of emotional requirements in the theory of constructed emotion are relating emotions to be constructed by software to the situations the software is meant to be used;
- The requirements that have been elicited by explicitly considering the theory of constructed emotion can be applied in designing interactive digital narratives and sociotechnical systems for various problem domains;
- The theory of constructed emotion can be supported by the practical methods and tools that support explicit usage of emotion words as emotional cues for situations and support describing situations and ascribing emotional qualities to situations.

Further research should enlarge and deepen the preliminary answers to the research questions provided here and should also validate the answers by real life case studies. We are planning to work out a visual design environment enabling to model situations along with their functional, quality and emotional goals. This design environment will be paired with a corpus of words and expressions referring to emotionally loaded situations to be created by utilizing natural language processing.

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References

[1] Rosalind W Picard. *Affective Computing*. MIT Press, 2000.

[2] Alessio Ferrari, Thaide Huichapa, Paola Spoletini, Nicole Novielli, Davide Fucci, and Daniela Girardi. Using voice and biofeedback to predict user engagement during requirements interviews. *arXiv preprint arXiv:2104.02410*, 2021.

[3] Grant Williams and Anas Mahmoud. Mining twitter feeds for software user requirements. In *2017 IEEE 25th International Requirements Engineering Conference (RE)*, pages 1–10. IEEE, 2017.

[4] Emitza Guzman and Walid Maalej. How do users like this feature? a fine grained sentiment analysis of app reviews. In *2014 IEEE 22nd International Requirements Engineering Conference (RE)*, pages 153–162. IEEE, 2014.

[5] Alexandra Fountaine and Bonita Sharif. Emotional awareness in software development: Theory and measurement. In *2017 IEEE/ACM 2nd International Workshop on Emotion Awareness in Software Engineering (SEmotion)*, pages 28–31. IEEE, 2017.

[3] https://dictionary.apa.org/mirror-technique

[4] https://www.pharaon.eu

[6] Sebastian C Müller and Thomas Fritz. Stuck and frustrated or in flow and happy: Sensing developers' emotions and progress. In *2015 IEEE/ACM 37th IEEE International Conference on Software Engineering*, volume 1, pages 688–699. IEEE, 2015.

[7] Wesley Brants, Bonita Sharif, and Alexander Serebrenik. Assessing the meaning of emojis for emotional awareness - a pilot study. In *Companion Proceedings of The 2019 World Wide Web Conference*, pages 419–423, 2019.

[8] Antonette Mendoza, Tim Miller, Sonja Pedell, and Leon Sterling. The role of users' emotions and associated quality goals on appropriation of systems: Two case studies. In *24th Australasian Conference on Information Systems*, 2013.

[9] Isabel Ramos and Daniel M Berry. Is emotion relevant to requirements engineering? *Requirements Engineering*, 10(3):238–242, 2005.

[10] Sonja Pedell, Leon Sterling, Hilary Davis, Alen Keirnan, and Gretchen Dobson. *Emotions around emergency alarm use: A field study with older adults. Report for Smart Services CRC Personalisation Project H5*. Swinburne University of Technology, 2013.

[11] Tim Miller, Sonja Pedell, Antonio A Lopez-Lorca, Antonette Mendoza, Leon Sterling, and Alen Keirnan. Emotion-led modelling for people-oriented requirements engineering: The case study of emergency systems. *Journal of Systems and Software*, 105:54–71, 2015.

[12] Tim Miller, Sonja Pedell, Leon Sterling, Frank Vetere, and Steve Howard. Understanding socially oriented roles and goals through motivational modelling. *Journal of Systems and Software*, 85(9):2160–2170, 2012.

[13] Jaak Panksepp. Emotions as natural kinds within the mammalian brain. *Handbook of Emotions*, pages 137–156, 2000.

[14] Paul Ekman. Are there basic emotions? 1992.

[15] Richard S Lazarus and Richard S Lazarus. *Emotion and Adaptation*. Oxford University Press on Demand, 1991.

[16] Nico H Frijda et al. *The Emotions*. Cambridge University Press, 1986.

[17] Andrew Ortony and Terence J Turner. What's basic about basic emotions? *Psychological Review*, 97(3):315, 1990.

[18] Jonathan Posner, James A Russell, and Bradley S Peterson. The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology*, 17(3):715–734, 2005.

[19] Stephan Hamann. Mapping discrete and dimensional emotions onto the brain: Controversies and consensus. *Trends in cognitive sciences*, 16(9):458–466, 2012.

[20] James A Russell. Core affect and the psychological construction of emotion. *Psychological Review*, 110(1):145, 2003.

[21] Matej Hochel, Emilio Gómez Milán, JL Mata Martín, A González, E Domínguez García, F Tornay, and J Vila. Congruence or coherence? emotional and physiological responses to colours in synaesthesia. *European Journal of Cognitive Psychology*, 21(5):703–723, 2009.

[22] Lisa Feldman Barrett. The theory of constructed emotion: An active inference account of interoception and categorization. *Social Cognitive and Affective Neuroscience*, 12(1):1–23, 2017.

[23] Lisa Feldman Barrett. *How emotions are made: The secret life of the brain*. Houghton Mifflin Harcourt, 2017.

[24] Paul Wells. 'perfect bridge over the crocodiles': Tacit contracts, listen thieves, and emotional labor in the animated fago. In *Emotion in Animated Films*, pages 14–34. Routledge, 2018.

[25] Syazwanie Filzah Zulkifli, Cheah Wai Shiang, Muhammad Asyraf bin Khairuddin, and Nurfauza bt Jali. Modeling emotion oriented approach through agent-oriented approach. *International Journal on Advanced Science, Engineering and Information Technology*, 10:647–53.

[26] Teresa Monahan, Gavin McArdle, and Michela Bertolotto. Virtual reality for collaborative e-learning. *Computers & Education*, 50(4):1339–1353, 2008.

[27] Marc Hassenzahl, Kai Eckoldt, Sarah Diefenbach, Matthias Laschke, Eva Len, and Joonhwan Kim. Designing moments of meaning and pleasure. experience design and happiness. *International Journal of Design*, 7(3), 2013.

[28] Katie Hoemann, Fei Xu, and Lisa Feldman Barrett. Emotion words, emotion concepts, and emotional development in children: A constructionist hypothesis. *Developmental Psychology*, 55(9):1830, 2019.

[29] Endel Tulving and Donald M Thomson. Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 80(5):352, 1973.

[30] John B Best. Cognitive psychology (5" ed.). *Belmost, CA: Brooks/Cole, Wadsworth*, 1999.

[31] Maria Gendron and Lisa Feldman Barrett. Emotion perception as conceptual synchrony. *Emotion Review*, 10(2):101–110, 2018.

[32] Hartmut Koenitz. Towards a specific theory of interactive digital narrative. In *Interactive Digital Narrative*, pages 91–105. Routledge, 2015.

[33] Kuldar Taveter and Eliise Marie Taveter. Case study on using colours in constructing emotions by interactive digital narratives. *arXiv preprint arXiv:2104.12154*, 2021.

[34] James Marshall. Agent-based modelling of emotional goals in digital media design projects. *International Journal of People-Oriented Programming (IJPOP)*, 3(1):44–59, 2014.

[35] Nina Rajcic and Jon McCormack. Mirror ritual: An affective interface for emotional self-reflection. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–13, 2020.

[36] Kerli Mooses and Kuldar Taveter. Agent-oriented goal models in developing information systems supporting physical activity among adolescents: Literature review and expert interviews. *Journal of Medical Internet Research*, 23(5):e24810, 2021.

[37] Kuldar Taveter, Leon Sterling, Sonja Pedell, Rachel Burrows, and Eliise Marie Taveter. A method for eliciting and representing emotional requirements: Two case studies in e-healthcare. In *2019 IEEE 27th International Requirements Engineering Conference Workshops (REW)*, pages 100–105. IEEE, 2019.

[38] Leon Sterling and Kuldar Taveter. *The Art of Agent-Oriented Modeling*. MIT Press, 2009.

[39] Tim Miller, Bin Lu, Leon Sterling, Ghassan Beydoun, and Kuldar Taveter. Requirements elicitation and specification using the agent paradigm: The case study of an aircraft turnaround simulator. *IEEE Transactions on Software Engineering*, 40(10):1007–1024, 2014.