Modeling Empathy in Embodied Conversational Agents*

Extended Abstract†

Özge Nilay Yalçın
School of Interactive Arts and Technology
Simon Fraser University
Vancouver, BC, Canada
oyalcin@sfu.ca

ABSTRACT

This paper is intended to outline the PhD research that is aimed to model empathy in embodied conversational systems. Our goal is to determine the requirements for implementation of an empathic interactive agent and develop evaluation methods that is aligned with the empathy research from various fields. The thesis is composed of three scientific contributions: (i) developing a computational model of empathy, (ii) implementation of the model in embodied conversational agents and (iii) enhance the understanding of empathy in interaction by generating data and build evaluation tools. The paper will give results for the contribution (i) and preliminary results for contribution (ii). Moreover, we will present the future plan for contribution (ii) and (iii).

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; **HCI theory, concepts and models**; **Empirical studies in HCI**; *Graphical user interfaces*; *Natural language interfaces*;

KEYWORDS

empathy; affective computing; embodied conversational agents

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1 INTRODUCTION

Recently, our social environment started to include technological interfaces and gadgets that started off as mere tools of communication to a participator of our social lives. Moreover, advances in the technology lead to the development of AI systems that can manage complex tasks, which started conversations of the ethical considerations revolving around systems that started to have a huge impact in our social environment. These advancements pushed the need of systems that should be able to understand social concepts as well as act socially.

Empathy, as the capacity to relate another's emotional state [20], is a complex socio-emotional behavior [33] that requires the interaction of high and low level cognitive behavior [18]. Studies conducted so far showed agents with the ability of showing empathy lead to more trust [9, 26], increased the length of interaction [7], help coping with stress and frustration [12, 37], and increase engagement [17]. Such a capability for computational systems would enhance the social interaction in educational applications, training environments, artificial companions, medical assistants and gaming applications, where initiating and maintaining a social interaction is of great importance.

In this research, we aim to develop a computational model of empathy to be used in artificial agents that are capable of multimodal interaction and implement it in an embodied conversational agent. We will be focusing on the body of work generated in psychology and neuroscience studies and ground our model on biologically inspired mechanisms. Such a mechanism for computational systems would enhance the interactive systems such as educational applications (tutoring systems), medical assistants, companions (dialogue systems), psychotherapy applications, gaming applications where social capabilities is of great importance. Furthermore, the capability of empathy may be used to reduce the cognitive bias in datasets and aid moral judgment in AI systems.

2 RELATED WORK

Empathy is studied by many disciplines, such as philosophy, psychology and neuroscience, which resulted in a number of different views and capabilities assigned to empathic behavior [18]. A prominent model of empathy by De Waal and Preston [20] proposes a multi-layered approach that allows for degrees of empathic behavior, as opposed to some narrow-views of empathy that only accounts for high-level empathic functions [4, 18]. This model, called Russian-Doll Model of Empathy [19, 20] suggests the components of empathy are built on top of each other due to evolutionary mechanisms. According to this model, empathy is the result of the interaction between low and high level processes. At the foundation of this model is the perception-action mechanisms which give rise to mimicry and affective matching. The mid-layer is composed of regulatory mechanisms that allows empathic concern and consolidation behavior. At the top of the hierarchy lies the cognitive mechanisms are responsible for perspective taking and targeted helping behavior.

Computational empathy research has been focusing on simulating and triggering empathy during the interaction between the

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user and the artificial agent [34]. Apart from a few exceptions, the state-of-the-art systems often don't rely on theoretical models and do not provide their own computational model of empathy. Some of them refer to sympathic emotions or the concept of "feeling sorry for" as empathic behavior, rather than full empathic capacity [9, 37]. Others rely on the implementation of appraisal mechanisms, as they are well-studied in the affective computing research [26, 27, 40]. Another view focuses on the formalization of empathic emotions [32] according to the appraisal model of emotions by Scherer [42]. A more complete model of empathy has been used by Asada [3], which follows cognitive developmental robotics approach but lacking implementation.

As empathic behavior highly linked with the ability to perceive and express emotions [41], the evaluation and perception of empathic behavior will be directly effected by the emotional communication capabilities of the agent. However, current research does not take the extent of the emotional communication capacity as a parameter in evaluation of the empathic behavior. Moreover, most of the research on computational empathy do not seem to keep up with the recent developments in the affective computing research that allows for dynamic recognition and expression of emotions. The communicational competence usually consist of pre-determined categories, that either rely on self-report [29], or multiple-choice selections that do not support dynamic interaction [7, 9, 37]. Although the interaction with robotic agents that shows empathy is more dynamic and open-ended in terms of using different modalities [34], the range of emotional expression and anthropomorphism varies extensively between studies that makes it hard to understand the effect of these low-level parameters to the overall empathic perception of the system [26, 39].

3 PROBLEM STATEMENT AND RESEARCH QUESTIONS

Computational models of empathy suffers from a clear description and theoretical positioning. As the research on empathy in artificial agents is a recently emerging field, the current models and techniques often fail to capture the broad spectrum of empathic behavior [34]. There seems to be a tendency in artificial empathy research to refer any system that can respond to affective signals as empathic, which ignores the cognitive and high level processes involved in empathy mechanisms. As a result of this lack of computational framework, a complete model and implementation of empathy is missing in the current research on artificial empathy.

Most of the implementation in computational empathy research rely on pre-determined scenarios with limited capabilities. Moreover, there is no consensus on how to evaluate the agent's empathic responses as well as the factors that affect the perception of empathy. Considering these problems in the current research practices, we developed some research questions to address these issues for this thesis.

1) **Can we model empathy in artificial agents? What are the requirements/components for an empathic agent?** This question lies the theoretical foundation of the empathy research in AI and is aimed to specify the components required for simulating empathy mechanisms in artificial agents.

2) **How can an empathy model be simulated in an embodied conversational agent?** This question is intended to answer questions related to the implementation of the empathy components separately and an empathic capacity as a whole. The state-of-the art methods from related research disciplines such as affective computing, social computing and other sub-disciplines of AI will be examined and a specific implementation for simulating empathy will be examined.

3) **How can we evaluate an empathic virtual agent?** Simulating empathy in artificial agents is a relatively new research area and the evaluation methods are not standardized. This research question is aimed to help defining standard evaluation methods deriving from psychology and HCI research.

3.1 Objectives and Scientific Contributions

As a result of answering these questions, this thesis is aimed to make three main contributions. The theoretical formulation and determining the requirements to implement the empathic components will be the main contribution of this proposed research. As the implementation of low-level empathic processes while understanding the range of emotional communication capacity was not addressed in the previous research, the proposed thesis will focus on the implementation and examination of the low-level processes with respect to empathic capacity. In the final step, the overall system will be evaluated in a real-time conversational scenario. As the research on computational models of empathy is relatively new, there is no consensus about the evaluation of the system and most research relies on the perception of the empathy rather than using a specific metric. Therefore, we propose to evaluate the perceived empathic behavior to test the overall empathic behavior and use best practices from HCI to evaluate the impact of the empathic capacity on interaction.

The contributions of the thesis will therefore consist of building a theoretical model of empathy for interactive agents, implementation and evaluation of the low-level components, determining the requirements for implementing the high-level components, and scenario-specific evaluations of the system. In the following sections we will cover the methodology, recent progress and future directions of this research.

4 METHODOLOGY

Due to the its hierarchical structure, the modeling of empathy requires multiple components that needs to be integrated to the system iteratively. The implementation is initiated with the theoretical model and the hypothesized components required for simulating empathy in a conversational agent. Following this theoretical foundation, each component of the proposed model should be implemented in different phases, where each phase includes a similar engineering design cycle. At each cycle, one component of the model will be implemented following the best practices and evaluated using standard HCI evaluation methods and perceptual/psychological experiments. Following the evaluations, the implementation may be adjusted before going to the next cycle. This process will be repeated to include: emotion communication, emotion regulation and cognitive components of empathy that was mentioned in the

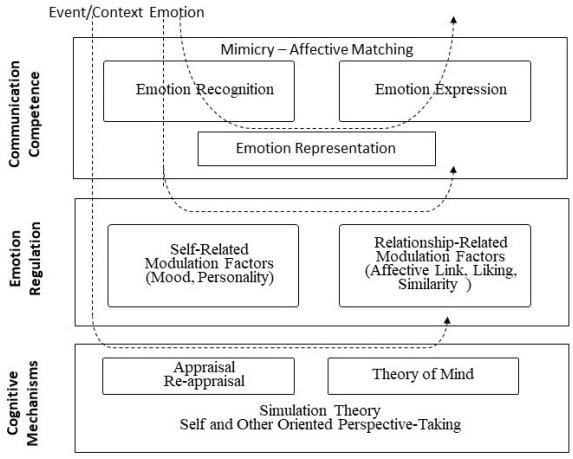

Figure 1: The proposed model of empathy [48].

previous sections. After finishing the implementation, scenario-specific evaluations will be conducted for the final evaluation of the theoretical model and its implementation.

Each phase will have corresponding contributions to the implementation and evaluation of the components of the proposed empathy model. As it can be seen in Figure 1, the first design cycle will be the implementation of the communication competence, and the second cycle will be the implementation of the emotion regulation that will be built on top of the previous implementation. After each design cycle, the evaluations will be done to refine both the model and the system and results will be published.

4.1 Theoretical Model

The initial contribution of the thesis is to provide a computational model of empathy that accounts for the wide spectrum of behaviors that are associated with empathic capacity from various research communities. In our recent submitted paper, we gathered the prominent views of empathy from psychology, neuroscience and philosophical perspectives in order to create a computational model of empathy that is suitable for embodied conversational agents [48]. Deriving from the theoretical and empirical background on empathy we categorized the components of this model as: emotional communication competence, emotion regulation and cognitive mechanisms (see Figure 1).

Similar to the Russian-Doll Model of Empathy by de Waal [19], our model consists of hierarchical components that function as interrelated mechanisms. According to this model, emotional communication competence is the foundation of the higher levels by providing the ability to recognize, represent and express emotions. Emotion regulation, which is the ability to regulate, suppress or enhance emotions according to regulatory mechanisms. Cognitive Mechanisms consists of higher-level capabilities such as appraisal processes, perspective-taking and theory of mind.

4.2 Implementation

After this theoretical formulation, our second question brings us to the next contribution of this thesis, which is the implementation of the theoretical model. As we mentioned earlier, the implementation will be an iterative process. Each design cycle will have corresponding contributions to the implementation and evaluation of the components of the proposed empathy model. In our previous paper, we mention possible implementations of a complete model of empathy using the best practices in affective computing, social computing and embodied conversational agent research [48]. In this thesis, we will focus on the emotional communication competence as the foundation of empathic behavior and how it changes the perception of empathy during interaction. Our goal is to create a dynamic empathic system that is capable of interacting with the user in real time.

There have been many advances on using multiple communication channels in dialogue system in the way of simulating humaneness in an artificial agent. However, engineering the usability of the system might have contradicting priorities compared with modeling an emotive believable character agent. One issue is to be able to find a good balance of the intensity and frequency of multimodal affective feedback to guide the dialogue flow. The timing and the quality of the feedback can have varying effects on different users. In this work, we propose a framework to incorporate affective input from the user while not sacrificing the perceived interactivity. We use conversational mirroring mechanisms as a way to generate baselines for interaction, that can be used to dynamically guide the user towards the end goal.

It has been shown on many studies that humans tend to treat computers as social actors, assigning them personalities, emotions and even social roles [38]. These high-level attributes are assigned with a complex set of verbal and nonverbal behaviour that is displayed in a given situation. A successful social interaction requires the proper recognition, interpretation and production of the social behaviours according to given situation [35]. Current research has been very successful on recognizing the high-level emotional and personality cues as well as understanding the meaning of the message from low-level behavior such as utterances [1, 5], the recognition of facial gestures [21], bodily gestures [2, 16], change the focus of our gaze [45], the vocal cues [25, 46] that accompanies our utterances [24] (for an extensive survey of many multimodal interaction techniques [22], affect detection [13, 49]). There has been also increasing efforts on producing the social signals in artificial agents, that can be recognized successfully by humans [11, 15, 23]. However, the selection of a proper response by the agent given the situation is still an unsolved problem. Many conversational agents use rule-based systems that relies extensively on handcrafted policies [10, 14]. Some of the data-driven approaches were successful at capturing personality [7, 28] and affective states [36, 43] in dialogue, however these attempts were neglecting the multimodal nature of dialogue. On the other hand, multimodal dialogue systems are neglecting the adaptation and dynamic nature of conversation [6, 10]. The impact of using multimodal interaction methods on user expectations and perceptions such systems are still poorly understood due to its dependence on differences in goals, expectations and perceptions of users. Moreover, users with varying cognitive difficulties such as adults with cognitive decline or people with disabilities may have different needs, where personalization and user adaptation has to be an essential part of the system. Our proposed research is intended to fill this gap by examining the multimodal

nature of conversation dynamics and generate a framework for an adaptable conversational agent.

4.2.1 Emotional Communication Competence. Currently, our socially situated virtual character system can perform a set of behavioral acts and context-specific dialogue in response to the speech input received from the user. We use the Smartbody character animation system [44], that is capable of providing face and body gestures, gaze, and speech output. In order to determine our agent's emotional expression repertoire, we are conducting initial experiments with our agent. For this we selected a set of natural body gestures, and facial gestures that correspond to a set of emotional tags. Using the amplitude, acceleration and duration of each gesture, we are trying to understand their effect on the perceived emotion in Pleasure-Arousal-Dominance (PAD) scale [31]. We conducted a preliminary study with 1890 ratings for facial emotions only and in the process of analyzing the results.The frequency and combination of those gestures will be examined by using facial gestures, bodily gestures and speech. The naturalness, believability and human-likeness of each gesture combination is also taken into consideration. For the next step, we would like to tie the emotion recognition system to the dialogue and gestural reaction component by using emotion representations.

4.3 Evaluation

Developing a reliable, sensitive and valid measurement method of empathy for artificial agents is not an easy task. As the research on computational models of empathy is relatively new, there is no consensus about the evaluation of the system and most research relies on the perception of the empathy rather than using a specific metrics. To test the empathic capacity of the system, ECA research often uses other but related terms, such as feeling sorry [8], feeling with [40], matching emotion [30] and caring [9]. However, the psychology research is more rich on measuring empathic capacity in humans in providing validated self-report measures such as Empathy Quotient and Systemizing Quotient [47]. There has been only one attempt to convert these measurements into ECA research but it is not applied yet [34].

We propose a combination of system-level and component level of empathy in interactive agents, following the HCI research approach. We would like to evaluate the perceived empathy of agents with differing levels of emotional communication capacity and compare the effect of multimodality, emotional repertoire and aesthetic factors.Moreover, we would like to examine the factors that effect the empathic behavior and the perception of it. Being a socio-affective phenomena, empathy is highly influenced by many factors that depend on features of the emotion, relationship, situation and features of the observer. HCI community has an extensive background on examining the effect of mood, personality and gender to the interaction. Empathy research so far only tackled the parameters on mood, liking and gender parameters. Aesthetic factors and embodiment factors which are very important in empathy are not examined at all,. After and during implementing and evaluating our system, we would like to put special emphasis on these factors as un-explored parameters.

5 CONCLUSION

Research in AI and especially in interactive systems can benefit from the development of a computational model of empathy by being able to act emphatically and being able to evoke empathic responses in the user. A computational model of empathy can help advance the interactive agents be more socially compatible, and can help us understand the address the ethical problems that we are facing in the artificial intelligence community today. In this thesis, we focused on whether this phenomenon can be modeled in artificial agents to promote the interaction with users and see whether equipping the system with such capabilities affect the empathic behavior in users. I will focus on multimodal interaction in conversation with a special emphasis on verbal behavior. I also want to examine the importance of the salience and affective components of the cues that can be performed by the system either providing anthropomorphic cues or by changing aesthetic components.

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