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Emotional Contagion in Human-Robot Interaction

Emotional contagion is particularly important in face-to-face interaction, and hospitality industry is no exception. Given that emotion is contagious, its effects in human-robot interaction remain largely unknown. This paper takes Sophia, the first humanoid robot that can display emotions, as a reference point, and investigates the emotional effect on online users' conative reactions. The results demonstrated that the expression of fear and disgust serves as the influential factors in affecting interests and engagements. Nevertheless, emotional contagion still deserves further exploration. Overall, this research contributes to the existing body of literature related to humanlike service robot, emotional contagion, and human-robot interaction.

Keywords: emotional contagion; humanoid robot; robot service; engagement; social media

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Background

Brain plays a crucial role in emotional processing, which enables humans to express emotions through the activation of facial muscles (Ekman, Friesen, & Hager, 2002). During any interaction, emotions help in transmitting information or conveying feelings. Most importantly, emotions are contagious (Hatfield, Cacioppo, & Rapson, 1993) and transmittable (Hennig-Thurau, Groth, Paul, & Gremler, 2006). This is particular important in the hospitality industry featuring direct interactions between customers and the staff since facial expressions have impacts on customers' complaining behaviours (Ngan & Yu, 2018), service satisfaction (Otterbring, 2017), and customer loyalty (Houston, Grandey, & Sawyer, 2018). However, unlike previously where services are delivered by only the human beings, advanced technology has revolutionized some of the service entities in the hospitality industry. For instance, Mandarin Oriental in Las Vegas employed Pepper as a service robot in addressing customer requests (Choi, Liu, & Mattila, 2019). Recently, a humanoid robot, Sophia, became the first robot that can display emotions (Goertzel, Mossbridge, Monroe, Hanson, & Yu, 2017).

Consequently, the service encounter is no longer limited to human-human interactions. Related issues include emotional contagion and emotional labour (Huang & Dai, 2010). With the help of artificial emotional intelligence, it can further reduce the negative syndrome resulted from managing the emotions constantly (Hochschild, 2012). Given the infancy of humanoid robots, customers' feelings towards the use of service robots becomes critical. While emotional contagion has been widely examined (e.g. Huang & Dai, 2010; Hatfield et al., 1993), it remains unclear in the case of human-robot interaction (HRI). Currently, since people barely have chances to have a real interaction with humanoid service robots (Tung & Au, 2018), information mainly comes from social media or news platforms. Popular sites such as Instagram enable users to express their behavioural responses through liking and commenting behaviours (Schreiner, Fischer, & Riedl, 2019). Whereas liking implies one's interest, commenting suggests a deeper form of engagement (Swani, Milne, Brown, Assaf, & Donthu,

2017). Echoing that, the contents of the online picture are often associated with users' behavioural outcome (Valentini, Romenti, Murtarelli, & Pizzetti, 2018). With the increase number of humanlike service robots, it calls an urgent need to investigate the emotional transduction in HRI. Thus, this research aims to investigate how robot emotions influence potential consumers' conative responses through social media.

Methodology

To bridge the relationship between robot emotions and potential consumer conative responses on social media, this study takes references from the official Instagram account of Sophia (@realsophiarobot). Emotional expression was investigated via *Microsoft Azure*, a facial recognition software. Specifically, data mining technique was conducted to extract the number of likes and comments for each post as well as the pictures from Sophia account. Other than that, comments of the posts were crawled for the further emotional analysis on the text. In total, @realsophiarobot has 124k followers with 327 posts. However, videos and pictures that contain other person or robots were excluded. Moreover, pictures with Sophia's side face or back as well as images that could not be detected through the software were screened out. Eventually, analysis of emotional detection was conducted based on 107 Sophia photographs.

Preliminary results

Humanoid robot's facial expressions were reported based on the six basic emotions (i.e., anger, disgust, fear, happiness, sadness, and surprise) and neutral. The strength of the emotion ranges from 0 to 1. A word to note is that facial expressions could be composed by several emotions with differing extent of strength. Descriptive statistics show that Sophia mostly presents a neutral face (M=0.56, Std=0.39), followed by happiness (M=0.32, Std=0.38) and sadness (M=0.07, Std=0.17). To examine how different emotion influences potential

consumers' conative reactions, multiple regression analysis was conducted. Regarding the liking behaviours, there was no significant regression equation, $F(7, 99)=1.516$, $p=.171$. Nevertheless, disgust ($p=.023$) and fear ($p=.020$) serve as significant predictors of number of likes. As for the commenting behaviours, a significant regression equation was found, $F(7, 99) = 2.926$, $p = .008$. Particularly, fear ($p \leq .000$) is found to be a significant predictor of number of comments.

Conclusion and future direction

Overall, the preliminary results revealed a significant difference in online users' conative reactions towards the humanoid robot expressing different emotion. Specifically, fear and disgust were found to be the salient factors in influencing people's reactions. Echoing the emotional contagion theory, when one expresses positive feelings, the surrounding people are likely to be affected (Hatfield et al., 1993). Potentially, it should be able to increase people's interest or engagement. However, when taking this notion into HRI, the present study revealed an opposite result. The findings implied that online users' commenting behaviours were enhanced owing to the expression of fear and disgust from the humanlike robot. Furthermore, online users even expressed a higher interest towards the humanoid robot with the display of fear through liking a post. Nonetheless, although measures such as number of likes can be used as a proxy to excitement or positive valence, it did not necessarily investigate the emotional contagion. To that end, future research on this paper would bridge this gap, potentially through text analytic technique (e.g. emotional analysis) to unveil if the emotion delivered from the humanoid robots could be reflected from texts. Also, through text analytics, it would uncover the impacts on the tourism/travel/hospitality industry. Finally, eye-tracking technology and EEG would serve as more sophisticated techniques to investigate consumers' reactions when they are looking at Sophia's photographs. Theoretically, this study bridges emotional contagion

theory into HRI and expanding the understanding towards emotional effects in such context. Practically, it offers valuable guidelines and suggestions to the hospitality management who intend to adopt the emotional robots in the service encounter.

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