The role of emotion in the study of humanoid social robots in the healthcare domain

Spekman, M.L.C.

2018

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Title: The role of emotion in the study of humanoid social robots in the healthcare domain

ISBN: 978 90 5383 354 4

Cover design: Robert A. Paauwe

Printed by: Gildeprint

The work in this dissertation was supported by the Creative Industry Scientific Programme of the Netherlands Scientific Organization (CRISP, Grant number: NWO 646.000.003).

VRIJE UNIVERSITEIT

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ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad Doctor aan
de Vrije Universiteit Amsterdam,
op gezag van de rector magnificus
prof.dr. V. Subramaniam,
in het openbaar te verdedigen
ten overstaan van de promotiecommissie
van de Faculteit der Sociale Wetenschappen
op woensdag 30 mei 2018 om 15.45 uur
in de aula van de universiteit,
De Boelelaan 1105

door
Maria Louise Carolina Spekman

geboren te Nieuwveen

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copromotor:	prof.dr.dr. J.F. Hoorn

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Chapter 1

General introduction

General introduction

In newspapers and scientific articles alike, the call for healthcare robots is increasing. To relieve the pressure of a shrinking workforce that has to take care of a growing number of patients, among others older adults, robots are presented as a possible answer. This warrants examination of how people perceive such healthcare robots. This dissertation contains a series of studies aimed at understanding the perceptions that people have of humanoid healthcare robots, and in particular how people's emotional state prior to interaction impacts those perceptions. This general introduction provides a brief overview of the current pressures in the field of healthcare as the context in which these robots will act, followed by an overview of current research on social robots in the healthcare domain, and specifically the role of emotions therein. To do so, we take a media-psychological stance, envisioning robots as a particular type of media figure, although robots are intended to be actually, physically present in 3 dimensions. Thus, they appear not on a screen as do most media figures, yet similar processes may be at work when engaging with a robot compared to engaging with a game or a movie character for which people may develop some forms of liking or bonding. This viewpoint is different from many other authors, who see the robot as an artificial instantiation of the human model, regarding the fictitiousness as a shortcoming rather than a value. In our view, a social robot is seen as a social entity, particularly when social robots have a humanoid appearance and are applied for communicative functions.

The next section will discuss emotions in media research, focusing on the role that emotions may play in the way we process what we see in the media as well as the role of emotions in forming social bonds or socio-affective relationships with media figures. We argue that such (socio-)affective relationships may similarly be formed with humanoid healthcare robots, especially if they fulfill social functions. The importance of emotional coping in the formation of such relationships is also discussed, followed by the theoretical model that is leading in this dissertation. We conclude with an overview of the studies and chapters presented in this dissertation.

Pressure on healthcare

Worldwide, the field of healthcare is facing enormous challenges due to ageing populations and shrinking resources. The number of people aged 65 or up is expected to increase from 8% in 2010 to 16% by 2050 (World Health Organization & US National Institute on Aging, 2011). Currently, Japan is the only country in the world where over 30% of the population is aged over 60, but projections are that many countries across Europe, North-America, and Asia will follow within the next 30 years (World Health Organization [WHO], 2015). According to the WHO (2015), there are two main reasons for this rapid ageing of populations in these regions. The first is improved longevity, mostly caused by the fact that the death rate amongst children has decreased due to improved public health and thus more children reach older ages (WHO, 2015; CPB Netherlands Bureau for Economic Policy Analysis [CPB], 2011). The second reason for population ageing is a steep decrease in global fertility rates, related to more children surviving and better access to contraception (WHO, 2015). Furthermore, improved healthcare practices also lead to higher survival rates (for instance, after a heart attack; OECD/EU, 2016). Thus, fewer children are born and the children that are born live longer than ever before, leading to a high number of older adults around the globe and consequently extra pressure on healthcare systems worldwide.

The current healthcare workforce, however, is not (fully) equipped to care for the anticipated number of older adults, according to the World Health Organization (2017). Apart from a misfit in what healthcare can offer and the specific demands of this particular age group (WHO, 2017), the number of people currently working in healthcare is insufficient to provide all the care that is needed. To meet labor demands, estimations suggest that between 20% and 30% of the working population in The Netherlands should be working in healthcare by 2040 (CPB, 2011). A big shortage of care personnel is imminent (Wu, Cristancho-Lacroix, Fassert, Faucounau, De Rotrou, & Rigaud, 2016). In fact, there is already an expected shortage of nursing staff in the United States by 2020 (Broadbent, Kuo, Lee, Rabindran, Kerse, Stafford, & MacDonald, 2010), and similar shortages are anticipated throughout Europe (OECD/EU, 2016). This increased demand for care goes hand in hand with rising costs for healthcare (CPB, 2011; OECD/EU, 2016).

To keep costs in check, solutions are sought in technologies such as telecare (also known as care at a distance), ambient intelligence, and robotics (CPB, 2011; Wu et al., 2016). The CPB Netherlands Bureau for Economic Policy Analysis (2011) estimates that technologies such as robots and telecare will lead to more efficiency, keeping costs within limits. Thus, robots may provide a possible solution to relieve some of the pressure on healthcare. However, care is not only about money. It also is about empathy of the caretaker and the emotional experience of the patient/client. It is essential, then, that we study the effect of people's (existing) emotional states on robots perceptions, because "the mere presence of robots in everyday life does not automatically increase the acceptance of these robots and the willingness to interact with them" (De Graaf, Ben Allouch, & Van Dijk, 2016, p. 96). The present research aims to contribute to an evidence-based deployment of robots in healthcare, studying how people's emotional state prior to interaction with a robot impacts their perceptions of that robot. Being ill or in need of care is not the most joyful experience and it might be that a negative emotional state *a priori* precludes the introduction of a healthcare robot for that person. If that is the case, then robots are not the best way to compensate for a reduced number of caretakers.

Robots and healthcare

Although most people have an idea of what a robot is, often based on science fiction, providing a precise definition of the term robot is not that easy. It has been said to originate from Czechoslovakia, as playwright Karel Čapek introduced the term 'roboti' (which was derived from 'rabota', meaning servitude, and 'rabu', meaning slave) in his play R.U.R. (Rossum's Universal Robots; Hiskey, 2012). As Hoorn (2015) explains, "A robot […] is a software agent that (inter)acts through electro-mechanical devices" (p. 234). Following this definition, a robot is – basically – a machine. However, not every machine is a robot, as a machine only functions by the grace of a person controlling the machine (i.e., direct input-output, such as a washing machine), while a robot is supposed to function autonomously, or semi-autonomously at the very least (Bartneck & Forlizzi, 2004). Thus, a robot is not dependent on some person controlling the robot, and it can function independently after being programmed (Broadbent, 2017). Furthermore, a robot is different from a virtual (software) agent in that it has a physical embodiment and takes up physical space (LaFrance, 2016), and studies show that even a virtual version of a robot leads to different effects than the embodied robot (e.g., Powers, Kiesler, Fussell, & Torrey, 2007; Krämer, Rosenthal-Von der Pütten, & Hoffmann, 2015). Thus, robots can be defined as physically embodied, (semi-)autonomous machines that can be programmed.

However, 'autonomous physical machine' is still a very broad term. The number of robots currently in existence is enormous and they come in many ways, shapes, and forms. Robots range from industrial and military robots (such as the robot arm depicted on the left in Figure 1) to household and toy robots (such as the dinosaur and vacuum robots in Figure 1). In the past two decades, the focus has shifted from robots as tools (i.e., industrial robots) to more social robots (Broadbent, 2017). Authors in the field of social robotics seem to agree that social robots are those robots that are able to interact in a humanlike manner, by mimicking human behavior, looks, and expressions (Broadbent, 2017; De Graaf et al., 2016). Humanoid robots are a subclass of social robots, characterized by the fact that they are made to resemble human-beings not only in behavior but also in form; they have a head, two arms, and two legs (Dautenhahn, 2013). These human-like looks make them susceptible to anthropomorphism (Broadbent, 2017), attributing human-like thoughts, emotions, or mental states to non-human objects (Epley, Waytz, & Cacioppo, 2007). The human-like looks of a robot provide cues that we interpret as social in nature (cf. De Graaf et al., 2016; Sah & Peng, 2015). Because robots are designed to look more and more humanlike (Dautenhahn, 2013), we focus on these kind of humanoid social robots in the present studies.

Figure 1. An industrial robot arm (left; AP Images, n.d.), WowWee's toy robot Roboraptor (middle; WowWee, n.d.), and iRobot's household robot Roomba (right; [Untitled picture of a Roomba vacuum robot, n.d.])

When it comes to robots that are developed specifically for use in healthcare, the number of available robots becomes smaller, yet there is still a large variety of available robots. Robots are currently being deployed for different groups of patients, ranging from children with autism to people in need of or recovering from surgery, and older adults

(Broadbent, 2017). Some of these robots are programmed to assist people in need of care, while other are programmed to monitor patients' health, or to provide companionship (Broadbent, Stafford, & MacDonald, 2009; Sharkey & Sharkey, 2012). Robot PEARL (Figure 2, left image), for example, is an assistive robot that guides older adults through their environment and reminds them to eat, drink, and take their medication (Pollack et al., 2002). Robot Hopis (Figure 2, middle image) is designed to monitor patients' blood pressure, blood glucose levels, and body temperature, although the robot has been discontinued due to disappointing sales figures (Broadbent et al., 2009). Robotic seal Paro (Figure 2, right image) has been more successful, as it can be found in many nursing homes across Europe, Asia, and the United States (Broadbent, 2017). Paro is created to keep (demented) older adults company by responding to their touch and sounds with cute noises, blinking eyes, and movement of the head and tail. In the studies reported in this dissertation, we will work with humanoid robots Zora and Alice. Robot Zora is a combination of SoftBank's/Aldebaran's robot hardware (Nao) and QBMT's user-friendly software (Figure 3, left image), which was created to perform both assistive as well as companionship tasks. Zora is used in hundreds of healthcare facilities, where she explains gymnastics exercises to elderly people, entertains (disabled) children, or keeps people company (Zorabots, n.d.). Robokind created robot Alice R50 (Figure 3, right image), also with assistive and companionship functions in mind. Even though both robots could theoretically perform multiple tasks, they were only used to perform companionship tasks in the studies in this dissertation.

Figure 2. Examples of healthcare robots: assistive robot PEARL (left; Andreyo, n.d.), monitoring robot Hopis (middle; [Untitled picture of Sanyo's Hopis robot, n.d.]), and companion robot Paro (right; [Untitled picture of AIST's PARO robot seal, n.d.])

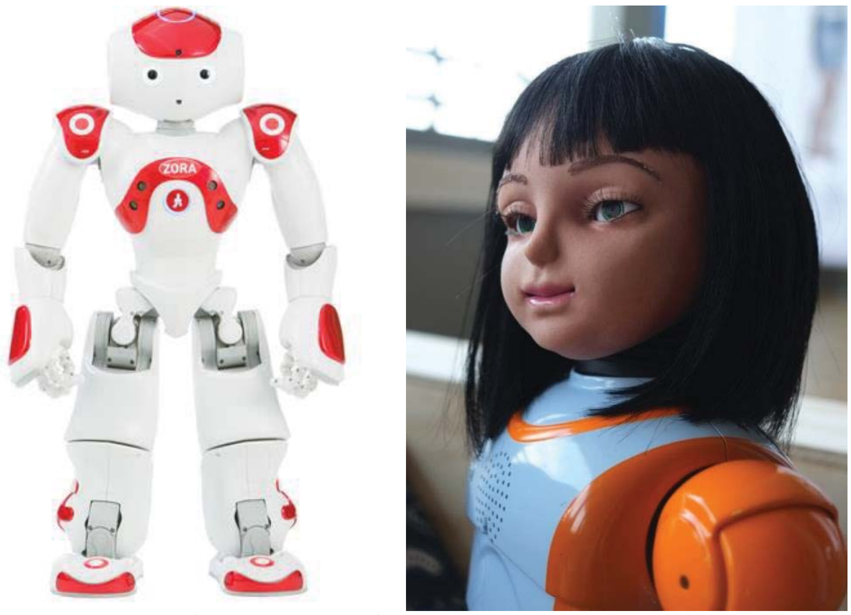

Figure 3. Robots Zora (left; [Untitled picture of robot Zora, n.d.]) and Alice (right; Spekman, 2015)

Historically, robots have mostly been studied from an engineering and computer science perspective, focusing on the technical possibilities and the development of software to model human behavior (Broadbent, 2017; Salem & Dautenhahn, 2017). For instance, a large part of robotics research focused on how to get robots to walk upright on two legs, or how to ensure that robots can grab objects by applying the right amount of pressure. However, as robots became more sophisticated and more readily available, part of the attention shifted from the robot itself to the robot's user and how that user interacts with the robot (Dautenhahn, 2013), as evidenced by the establishment of a large number of human-robot interaction conferences and symposia since the late 1990's and early 2000's (Goodrich & Schultz, 2007). Research in the field of human-robot interaction (HRI) that focuses on the user has grown substantially over the last few decades.

Within the field of HRI, a distinction is made between robot-centered HRI (which views the robot as an autonomous entity that needs human input to fulfil its tasks) and human-centered HRI (which views the robot as an entity that should perform its tasks within the boundaries of acceptability determined by humans) (Dautenhahn, 2007), and it is this latter approach that is taken in this dissertation. However, human-centered HRI primarily focuses on design features and how these features of the robot affect the emotions, cognitions, or acceptance of the user. For instance, Tung (2016) studied the effect of human-likeness of robots (in terms of appearance) on the attitudes towards those robots among children. Results of displaying still images of robots showed that robots looking like humans are rated more socially attractive, while results of a replication with moving robot images suggest that others cues (such as facial expression, speech, and gestures) may be more important than a human-like appearance. Heerink, Kröse, Evers, and Wielinga (2006) looked at those other cues, and found that a more socially communicative robot (i.e., a robot that used more of such cues) invoked more interaction with the older participants than the less socially communicative robot, yet statistical results showed no difference in acceptance of both versions of the robot.

Studies such as these show that robot features may be very important in influencing user cognitions and emotions with regard to the robot, yet, the robot is still pretty much the focus of attention, and not the user's perspective. Furthermore, these kind of studies often leave aside that users take their prior emotions and attitudes with them when engaging with a robot. Several authors have suggested that a user's prior emotion is important when studying perceptions of robots (e.g., Broadbent et al., 2009; Stafford, MacDonald, Jayawardena, Wegner, & Broadbent, 2014). Thus far, however, such a perspective has not yet been implemented in research with robots, while many healthcare situations are in fact highly emotional. Therefore, the studies in this dissertation focus on the role of existing, prior emotions in influencing perceptions of robots. To that end, the next section discusses the ways in which emotions may influence our thinking and processing of media encounters.

Emotions and media

Historically, emotions and affect have not always played the role in media research that they do nowadays. Especially in mass communication research, the role of emotions and affect have long been underappreciated because informative media sources (such as the news and political campaigns) were supposed to present information only, and therefore the cognitive level of processing information by the audience was the focus of interest (Konijn, 2013). With the rise of entertainment media, research into the effects of such media on an affective level and the role of emotions also grew. In this respect, quite some attention has been paid to the effects of media on fear/anxiety (e.g., Cantor, 2009), aggression (e.g., Anderson et al., 2010; Ferguson & Killburn, 2010; Konijn & Ferguson, 2015), and enjoyment (e.g., Nabi & Krcmar, 2004). Media may thus have effects on the audience's emotions, and this may be (partially) caused by message characteristics. For instance, adding a fear appeal to a persuasive message may induce fear among the message's recipients (for a recent meta-analysis of fear appeal effects, see Tannenbaum et al., 2015). Yet, as we will discuss in the next sections, emotions and affect may also influence the way people choose which media to expose themselves to, the way they process media content, as well as being part of the process of bonding with media figures. For elaborate overviews of the role of emotion and affect in media research, interested readers are referred to a handbook on emotions and mass media (Döveling, Von Scheve, & Konijn, 2010) and chapters by Konijn (2008), Konijn (2013), and Nabi (2016).

The role of prior emotions in media use

As said, the content of media messages may arouse specific emotions after exposure to that media content. However, media do not only arouse emotions, but emotions may also affect how people chose to expose themselves to certain media content, and how they process that media content. With regard to the effect of emotion on *selective exposure* to media content, one of the most well-known theories is Zillmann's (1988) mood management theory. It predicts that people aim to maintain positive moods and change negative moods by exposing themselves to certain media content. However, because mood management theory fails to explain why some people expose themselves to sad movies, Knobloch (2003) offered an adjusted version of the theory: the mood adjustment theory. Knobloch explains that some moods are not simply adjusted (cf. mood management theory), but rather that the mood may be maintained (and thus not hedonically optimized) if the person anticipates that the mood may be functional in a future situation. For instance, experiencing stress may be useful in anticipation of an exam, and even though instant relief of stress is possible, it makes sense to postpone this until after the exam (Knobloch, 2003). Thus, our emotions may be an important factor in deciding what we expose ourselves to in terms of media content.

Besides the influence of emotions on selective exposure to specific media content, emotions are also found to have an important influence on our *processing* of that media content. Yet, different theories have been coined regarding how emotions may influence the way we process media messages. Konijn (2013) argues that the experienced emotions and affect prior to or in response to media exposure, may lend ‘realness’ to the processed media content (i.e., ‘if I feel, it must be real”; Konijn, Walma van der Molen, & Van Nes, 2009, p. 334). Konijn explains that information processing occurs in parallel via two pathways in the brain: The lower pathway, which runs through the amygdala and is involved in emotion processing, and the higher pathway, which is related to conscious reflection and reappraisal. The lower pathway is faster than the higher pathway, and so it might be that the emotional messages are processed so quickly through the lower pathway that we react even before we have put effort into processing all information in the reflective part of the brain (Konijn, 2013). Because this lower pathway responds so quickly and reflecting on it takes cognitive effort and time, media messages may be processed and remembered differently when they contain emotional content, which may lead to biased perception and storage of information (Konijn, 2013). Konijn and colleagues (2009) demonstrated that such a bias resulted in higher levels of perceived realism of a fake-documentary in emotion-aroused individuals as compared to non-aroused individuals, even though they were told beforehand that the media footage was fake. Such parallel processing and biasing influences of emotions may be exactly what is at play when people respond to social robots in an emotional context. Through such parallel processing, researchers have explained how lonely elderly became attached to the girl-like robot Alice (e.g., as featured in the documentary ‘*Alice Cares*’ by Doolaard & Burgers, 2015). The felt pain of severe loneliness guided their perceptions of the robot, while knowing it was ‘just’ a robot and not a real human being. The awareness that the robot was not real (i.e., the higher pathway reflective thoughts on the non-human nature of the robot) was eventually of less importance than fulfillment of their emotional needs (Hoorn, Konijn, Germans, Burger, & Munneke, 2015; Van Kemenade, Konijn, & Hoorn, 2015).

Another way in which emotions may influence the way in which we process media content is related to the availability of cognitive resources that we need to process information. According to the limited capacity model of motivated mediated message processing (or LC4MP; Lang, 2000; 2009) we need cognitive resources to process media information, while only limited resources are available. Information that is processed needs to be encoded and stored in the brain before it can be retrieved from memory, and all of these steps require cognitive resources (Lang, 2009). Emotions (either aroused before or aroused by the content of the media message) may influence resource allocation through the activation of either the aversive system (related to negative emotions) or the appetitive system (related to positive emotions). When the aversive system is activated, resources are first automatically allocated to encoding (to quickly identify the threat) and then allocated to retrieval, so the person can quickly decide on how to deal with the threat (Lang, 2006). Activation of the appetitive system, however, is related to the desire to take in as much information as possible, so as many resources as possible will be allocated to encoding and storage of information (Lang, 2006).Thus, the valence of an emotion (i.e., whether the emotion is positive or negative) affects the allocation of resources for the processing of information in the brain.

A line of thought that is similar to the limited capacity model of motivated mediated message processing is found in the broaden-and-build framework (Fredrickson, 1998; 2001), although this framework focuses primarily on the function of positive emotions. The broaden-and-build framework argues that positive emotions are related to a desire to take in as much information as possible, whereas negative emotions function to narrow one's view to the threat or problem at hand. In narrowing one's focus, negative emotions thus limit one's repertoire of available thoughts and actions (Fredrickson & Branigan, 2005). For instance, when a driver is angry because another driver cut him off on the road, the driver will only think of a very limited number of available actions to undertake (such as honking, cursing, or taking revenge by cutting the other driver off in return). Positive emotions, on the other hand, lead to broadening of the thought-action repertoire (Fredrickson, 2001). Thus, the number of available thoughts and actions that come to mind in a person in a positive emotional state will be larger than the number of thoughts and actions in the mind of a person in a negative emotional state. We may expect that this broadening of one's focus may also apply to social robots in that people in a positive emotional state may see more options and possibilities to interact with the robot than those in a negative emotional state. People in negative emotional states are then expected to be more negative about such robots, because they only have a limited number of available thoughts and actions available to them. In other words, the valence of the emotional state one is in would determine the extent to which one is open to interact with a robot. Therefore, the broaden-and-build framework is one of the important frameworks that are tested in the studies reported in this dissertation.

Besides the effects that emotional valence may have on the way we process and perceive information presented in the media, there are also theories that assume that not emotional valence, but rather discrete emotional states are important in processing and perceiving media content. Discrete emotions – such as anger, happiness, fear, sadness, or surprise – originate from a pattern of appraisals of one’s environment (i.e., an object or event). Every situation is appraised on a number of dimensions (such as personal relevance, agency, control, coping potential, etc.; e.g., Frijda, 1986; 2007; Smith & Ellsworth, 1985), and every discrete emotion is characterized by a distinct pattern of appraisals (Roseman & Smith, 2001). One of the theories that applied this discrete emotion perspective on media use, is the emotions-as-frames approach (Nabi, 2003). According to this approach, emotions may act as frames that influence the accessibility of information (Nabi, 2003). Certain patterns of appraisals are associated with specific states of action readiness. In simple terms, action readiness can be described as an urge to behave or think in a specific way, based on the appraisals of the situation (Frijda, 1986; 2007). The combination of certain appraisal patterns and state(s) of action readiness are generally experienced as discrete emotions. If we use the emotion of fear as an example, then we see that the situation has been appraised as threatening to the self, and this appraisal leads to the desire to eliminate or alleviate this threat. In others words, fear leads to a desire (i.e., action readiness state) to diminish the threat. Media messages may contain features that may play into these appraisal patterns, and in that way may act as a frame for processing the content of the message. Continuing with the fear example, threatening information in the message may invoke fear in the recipient, which in turn leads to selective attention to threat-related information in the message, but also to the retrieval of related information in the memory related to (alleviating) the threat (Nabi, 2003). When testing the same message with different emotional frames (i.e., an anger vs fear frame), Nabi (2003) found that participants in the two frame conditions had retrieved different solutions from memory, had different information needs, and had different policy preferences with regard to solving the drunk driving problem that was addressed in the text. Thus, Nabi (2003) shows that discrete emotions may function as a framework for different processing of information. Such a line of thought might be fruitfully extended to the case of interacting with social robots, in that existing prior emotions may lead individuals to think in certain directions about the robot and how to interact with it.

Nabi's 'emotions as frames' approach is in line with the idea of appraisal theories of emotion (e.g., Frijda, 1986; 2007; Lazarus & Folkman, 1984) that the appraisals associated with an emotion may lead to a tendency to interpret different situations in the same light (in terms of appraisals). The appraisal-tendency approach (Lerner & Keltner, 2000; 2001) is also based on the idea that every emotion is associated with a certain pattern of appraisals. For instance, anger is characterized by appraisals of other-responsibility, individual control, and certainty about the situation (Lerner & Keltner, 2000). Thus, emotions may direct cognition. Lerner and Keltner (2000; 2001) hypothesized that the appraisals associated with an emotion may cause a predisposition to appraise future situations in line with the core appraisals associated to the emotion. Thus, a situation that is appraised and leads to sadness will create a tendency to appraise future, unrelated situations in a similar fashion. In the case of anger, a person's appraisal of other-responsibility may then transfer to an unrelated situation, thereby creating a tendency to blame others (Lerner & Keltner, 2000). In contrast, fearful people appraise their situation as uncertain and low in self-agency, and are generally more pessimistic about future situations due to the transfer of these appraisals (Lerner & Keltner, 2000). Based on this appraisal-tendency approach, it seems conceivable that people in different emotional states have different appraisal tendencies when they are confronted with a social robot, as the robot is then appraised in light of the existing emotional appraisals. Therefore, the appraisal-tendency framework is, next to the broaden-and-build framework, one of the key theoretical frameworks that is tested in this dissertation.

The role of affect in the formation of socio-affective relationships with media figures

The theories discussed in the previous section suggest that our emotional states may have a clear impact on the way we perceive and process the world around us as presented through the media. However, media messages are often presented to us by or through characters, such as news reporters, actors, or avatars. Research in the realm of emotion and affect has also focused on the way we engage or involve ourselves with such media characters. Following a number of studies into relating to media figures, Konijn and Hoorn (2017) propose a theory of affective bonding to explain why and when people form socio-affective bonds with media characters, even if the recipient is aware that these characters are fictional and/or non-human. Their theory of affective bonding consists of a set of four propositions about the mechanisms at work in the forming of such relationships with media figures. First of all, humans tend to instantaneously respond in communicative ways to humanlike appearances, such as media characters, more-or-less *as if* they are human. Extensive research has shown that humans tend to apply human schemata without much thoughtful mental processing (e.g., Epley et al., 2007; Nass, Steuer, & Tauber, 1994; Reeves & Nass, 1996). Lifelike humanoid robots may even be attributed perceived agency (e.g., Alač, 2016; Midden & Ham, 2012), which might be facilitated by a robot's facial expressiveness (Broadbent et al., 2013; Konijn, Hoorn & De Rie, 2017). Second, Konijn and Hoorn (2017) propose that affective bonding is conditional and only takes place when the interaction with the media character is deemed relevant for the recipient (i.e., if it potentially may fulfill or threaten a certain need the recipient might have). Thirdly, if bonding with the media character is relevant, this may come with affect or emotions. Illustrative is the painful loneliness of the old ladies featured in the documentary *Alice Cares* (Doolaard & Burgers, 2015) that may have driven them to become friends with the humanoid social robot Alice (Hoorn et al., 2015; Van Kemenade et al., 2015). The emotional state will feed the feeling that the relationship with the media figure feels like a real relationship (cf. Konijn et al., 2009 for empirical evidence of emotional states enhancing the perceived realness of media content). The fourth and final proposition is that the media character (or the relationship with that character) should afford particular action possibilities or functionalities (affordances; Gibson, 1977) that help the recipient attain his/her goal: "Affordances shape potential relationships with a media figure" (Konijn & Hoorn, 2017, p. 11). For example, a televised newscaster affords listening to information about politics and the economy, whereas an action hero affords excitement and adventure. Robots should offer designed affordances that match what someone wants to accomplish with the robot, for example to do physical exercises (Hoorn et al., 2015). Affordances influence the willingness to use a tool or medium and also affect how engaged individuals are with a media figure "as a friend" or otherwise (Van Vugt, Hoorn, Konijn, & De Bie Dimitriadou, 2006). Following these propositions, it is a priori possible that people may form affective relationships with healthcare robots as they do with other media characters, especially if the robot has humanlike characteristics and has affordances that are relevant for the user (with the difference that most media characters are not physically present in the same room as the recipient, while the robot is). Therefore, the next section discusses some of the theories on the role of emotions and affect in how we form relationships with media characters (which may be applied to robots in the healthcare domain as well).

Historically, affective disposition theories (Raney, 2004; Zillmann & Cantor, 1976) have been applied to explain why people like or dislike specific characters which primarily focused on the moral dimension. In brief, disposition theories state that we like to see good things happen to liked characters and bad things to disliked characters. The liking or disliking then depends on whether the character is considered morally good ('the hero') or evil ('the villain') (Zillmann & Cantor, 1976; Raney, 2004). However, in contemporary media fare, most characters are not unidimensional, not purely good or purely evil. Many characters are more ambiguous in nature, or are morally good in some respect, but morally bad in some other aspect (such as Dr. Gregory House from the fictional TV show *House*). Disposition theories such as the ones described here do not explain why some people *do* like such 'bad characters' or ambiguous media fare that portray evil and ambiguous characters. Therefore, Konijn and Hoorn (2005) proposed a multidimensional model of Perceiving and Experiencing Fictional Characters (PEFiC). This theoretical framework explains how both the design of fictional characters (such as TV and movie characters) and user characteristics affect user engagement with those characters. Three phases are distinguished in PEFiC: *Encode*, *compare*, and *respond* (see Figure 3). In the first phase, the *encode* phase, the user observes the character (depicted on the far left under *user perception process* in Figure 3) and forms an image of what the robot is/does in terms of ethics, aesthetics, and realism. In the next phase, *compare* (the middle part of Figure 3 under *user perception process*), the user compares the representation of the character that was formed in the *encode* phase to his/her own goals, motivations, and experiences. This is where affect and emotion come into play. The user checks whether engaging with the character is relevant for achieving his/her goals and, if yes, whether it will possibly lead to positive or negative outcomes (in terms of achieving one's goals; this is referred to as valence). Furthermore, the user also compares the character to him-/herself, to evaluate the extent to which features of the media figure are similar or dissimilar to the user's own characteristics. Thus, the result of the *compare* phase is an assessment of the character's relevance, valence, and similarity. In the *response* phase, finally, the user forms feelings of involvement and distance towards the character based on the perceptions in the earlier phases. Note that, even though it may intuitively feel like involvement and distance are two extremes on an engagement-continuum, empirical evidence shows that involvement and distance are in fact two distinct, parallel processes (e.g., Konijn & Bushman, 2007; Konijn & Hoorn, 2005), also in engaging with social robots (Hoorn & Winter, 2017). Finally, the trade-off between involvement and distance determines the extent to which the user appreciates the character (Konijn & Hoorn, 2005).

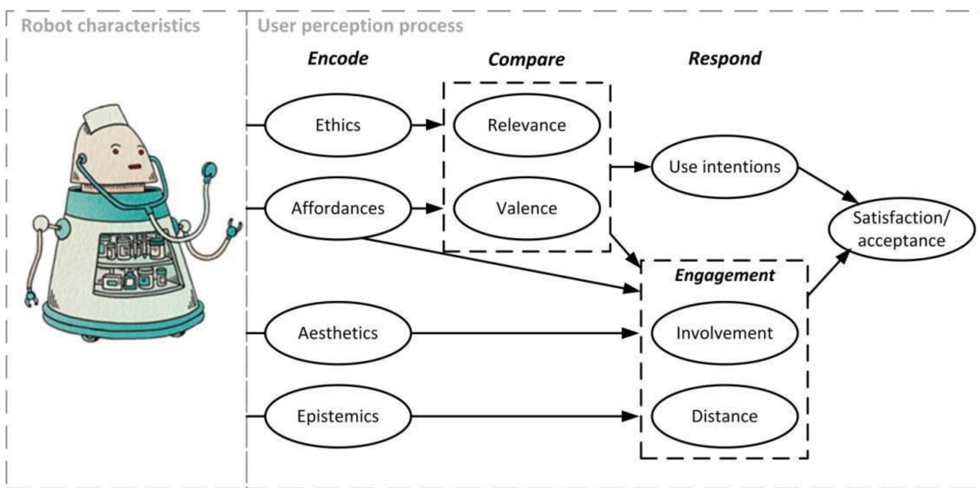

Figure 3. Framework for Interactively Perceiving and Experiencing Fictional Characters (I-PEFiC, adapted and simplified version based on Van Vugt et al., 2009)

The PEFiC-model as described in Konijn and Hoorn (2005) is based on fictional characters in traditional media, such as movie and television characters. However, robots are characterized by the presence of a physical embodiment, which enables interactivity between robot and user. I-PEFiC is an adapted version of the PEFiC framework to account for the interactive nature of many characters in new media environments (Van Vugt, Hoorn, & Konijn, 2009; Hoorn & Winter, 2017). In line, several dimensions were added, that is, the dimensions of affordances (in the *encode* phase) and use intentions (in the *response* phase) (Van Vugt et al., 2006). Affordances then refer to the action possibilities that a user perceives in the agent, as we here apply to a social robot. For instance, a user may perceive that a social robot affords the option to have a conversation with the user. Furthermore, affordances in the I-PEFiC model are not only encoded in terms of action possibilities, but also in terms of the extent to which these action possibilities (potentially) aid or hinder the user in achieving a goal. Use intentions were added (in the *response* phase) as they were found to be an important predictor of actual technology use (e.g., based on the Technology Acceptance Model; Davis, Bagozzi, & Warshaw, 1989) (Van Vugt et al., 2006).

Emotions and robots

In the above we have discussed several theories on how people may form emotional bonds with fictional characters, and one in particular that focuses on embodied agents: I-PEFiC (Van Vugt et al., 2009). It is quite likely that we may similarly form bonds with robots, especially if we consider that robots have a physical embodiment that we can see and touch, while most media figures are only observed via flat screens. Previous studies have shown that the I-PEFiC framework can indeed be applied to social robots (e.g., Paauwe, Hoorn, Konijn & Keyson, 2015; Hoorn & Winter, 2017). We therefore use the I-PEFiC framework in this dissertation to assess the components of affect-based perceptions of healthcare robots. One of the aims of the current dissertation is to connect the literature on forming affective relationships with media figures – such as social robots – to the literature on (the effects of) emotions, appraisals, and emotional coping.

Perceptions of social robots may be particularly susceptible to influences of users' emotions in a healthcare context, which is more often than not emotionally taxing. Therefore, we assume that social robots applied in a healthcare context will often be encountered by users in (intense) emotional states. This makes it important to study how emotions prior to interacting with a robot may influence perceptions (and, assumingly, acceptance) of a healthcare robot someone is about to encounter. Yet, but few studies in the field of robotics focused on the potential influence of prior affect or emotions on perceptions of robots. Stafford and colleagues (2014) studied the use of a robot in a retirement village and found that people with initial positive attitudes about robots were more likely to use the robot than people with initial negative attitudes about robots. Broadbent and colleagues (2010) compared reactions to blood pressure readings by a medical student to those by a medical robot. They found that people felt less comfortable with the robot than with the student while objective blood pressure readings were equally accurate. Furthermore, these authors found that participants with positive prior attitudes and affect about robots (in general) responded more positively to the medical robot than participants with less positive prior attitudes and affect about robots. It thus seems likely that user perceptions of healthcare robots may be affected by the emotions that users experience prior to the actual interaction with a robot. That is, prior emotions and affect in general do seem to influence people's responsiveness to a healthcare robot, but it remains unclear whether this effect is similar for different, distinct emotional states, including those of similar emotional valence (i.e., sadness, anger, and fear all have negative valence but are associated with different appraisal patterns). Additionally, it is unclear *how* exactly the experienced emotions of the user may affect the perceptions of a healthcare robot with whom one is about to interact. Therefore, the studies reported in this dissertation aim to examine the influence that prior emotions may exert on the perception of a social robot in a healthcare context.

Furthermore, the emotionally stressful nature of most healthcare situations makes that not only emotions, but specifically also the way in which people cope with their emotions may play an important role in affecting perceptions of healthcare robots. Because most healthcare situations are emotionally taxing – particularly chronic conditions (Karademas, Tsalikou, & Tallarou, 2011) – chances are high that people feel the need to cope with that stressful situation. Coping, according to Lazarus (1999), is "the effort to manage psychological stress" (p.111), especially when this stress is experienced to exceed one's available resources (Lazarus & Folkman, 1984). Coping has been an important topic of study in both emotion and stress research. Stress and emotion have long been considered two separate fields, while stress and emotions are in fact closely related (Lazarus, 1999). In the field of stress research, the literature on coping is abundant, yet there is no existing literature on the influence of coping on perceptions, let alone perceptions of media figures or robots. In media research, the literature on emotional coping is scarce to begin with, and – if available – mostly focused on how media content may be used to regulate mood, to adjust or to maintain emotions (see Nabi, So, & Prestin, 2010 or Schramm & Cohen, 2017 for overviews). To our knowledge, there is no current research on how emotional coping may influence perceptions of media in general, or perceptions of media figures and robots in particular. Therefore, this dissertation also aims to understand how *coping* with emotions (and the specific ways an individual copes) may influence a potential user's perceptions of robots in healthcare contexts.

In the coping literature, a distinction is made between two important types of coping strategies: problem-focused coping and emotion-focused coping (Lazarus, 1999; 2001). Problem-focused coping strategies are strategies aimed at changing or solving the problem itself, which changes the problematic (or stressful) relationship between the self and the environment (Lazarus, 1999). For instance, one may choose to talk to the person that aroused sadness to change the situation (Chang, 2013). Emotion-focused coping strategies are aimed at changing or regulating the emotion itself, without explicitly doing anything about the assumed underlying problem (Lazarus, 1999). For example, one may change the way one feels about a situation by changing the way one appraises the situation (i.e., cognitive reappraisal), or try to avoid thinking about the stressful situation (i.e., denial or avoidance). When people need to cope with their emotional situation, they may choose to use either problem-focused or emotion-focused coping strategies, or a combination of both (i.e., people may choose both kinds of strategies in parallel; Lazarus, 2006). Generally, however, people are more likely to use problem-focused coping strategies when they experience that they have control over a situation, or that they are able to change the situation, while feelings such as powerlessness and uncontrollability are often associated with emotion-focused coping strategies (Chiavarino et al., 2012; Glanz & Schwartz, 2008; Lazarus, 1999; Lazarus & Folkman, 1984). Based on this information, we studied the role of both kinds of coping strategies in influencing the perceptions of social robots in healthcare robots, which we report about in the next chapters.

Outline of the dissertation

In the studies reported in this dissertation, the basic theoretical framework can be summarized as shown in Figure 4. The basic starting point for all studies is a user's prior emotional state: we studied different discrete emotions, such as happiness, frustration, sadness, and anger in how this affected a potential encounter with a social robot in a healthcare context. Based on appraisal theories of emotions, we expected that these emotional states differed on appraisals. Following the appraisal tendency framework (Lerner & Keltner, 2000; 2001), we expected that the *appraisals* that were associated with the prior emotions would mediate the effects of those emotions on perceptions of the social robots. We also expected that *coping strategies* would mediate the effects of emotions on perceptions of social robots.

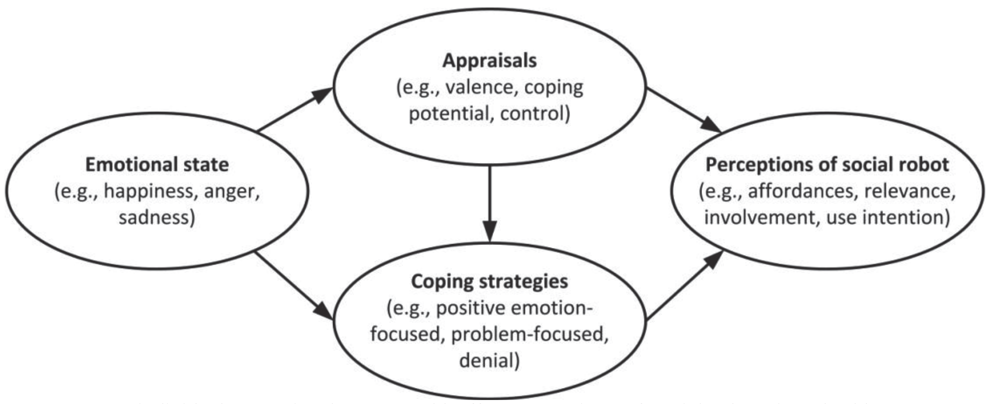

Figure 4. An individual's emotional state would affect perceptions of social robots in a healthcare context, mediated by appraisals and coping.

In this dissertation, four empirical studies examined how prior emotions, appraisals, and coping strategies would influence perceptions of a social robot in a healthcare context. In *Chapter 2*, we compared mechanisms of emotional influence based on two theoretical approaches: the valence-based broaden-and-build approach (Fredrickson, 1998; 2001) and the appraisal-based appraisal-tendency approach (Lerner & Keltner, 2000; 2001). We performed an experiment in which we manipulated participants' emotional state so that the emotional states differed in valence (i.e., negative vs. positive), but also with respect to other appraisal dimensions. Participants were asked to recall one of four different emotional states (frustration, sadness, happiness, or hope), or a relatively neutral state (as control condition). Then, they read about healthcare robot Alice in a newspaper article and we assessed participants' perceptions of this robot, using the I-PEFiC questionnaire. Together with measurements for prior emotions, we could verify which predictions of the two emotion theories offered the best explanation for the effects on I-PEFiC perceptions.

In *Chapter 3*, we zoomed in on the role of emotional appraisals and emotional coping. Appraisals associated with emotions were expected to have an effect on the participants' choice of coping strategies. Particularly, feelings of control and power are associated with the use of problem-focused coping strategies (Chiavarino et al., 2012; Glanz & Schwartz, 2008; Lazarus, 1999; Lazarus & Folkman, 1984). Therefore, we manipulated emotional states as well as ease-of-coping (resulting from Study 1) to create different appraisal patterns by asking participants to recall from memory an emotional situation related to healthcare. To establish causality and retain control over potential confounds, we performed a lab experiment in which we manipulated emotional state (angry vs. sad) and ease-of-coping (hard- vs. easy-to-cope-with situation), which we compared to a control group that recalled a relaxed state. After recalling and describing the emotional situation, we assessed the coping strategies that participants used in that situation, followed by a mock-up interaction with robot Alice.

In the studies presented thus far in *Chapters 2* and *3*, the robot was not physically present. However, the interactive component of I-PEFiC suggests that the mere physical presence of a media figure and the options for interaction that it affords may sort different effects compared to passively observing media characters. Therefore, we performed another study (reported in *Chapter 4*) to examine how the physical presence of the robot would affect the pattern of results from the studies thus far. In other words, how would the mere presence of the robot shape the effects of participants' prior emotions, appraisals, and coping on perceptions of a healthcare robot? In Study 3, participants were unaware of the fact that they would meet a robot. However, it turned out that meeting a physically present robot unexpectedly, overruled the previous emotion manipulation. To rule out such potential surprise effects caused by the unexpectedness of meeting a social robot halfway the study, we conducted Study 4.

Study 4 replicated Study 3 in a similar experimental design, yet this time participants were informed beforehand about meeting a physically present robot during the study. We incorporated this information in the study protocol (see *Chapter 4*). In doing so, we aimed at further testing the insights gained from our previous studies into the effects of emotions and emotional coping when people actually meet a robot face-to-face. Thus, *Chapter 4* reports on two lab experiments, similar in design, but different in the amount of knowledge that participants had upfront.

The results of all four empirical studies are summarized in the General Discussion in *Chapter 5*, along with a discussion of the implications of the results in a broader theoretical context. Generally speaking, the results show that prior emotional states do not directly influence how people perceive a social robot in a healthcare context. Rather, emotional appraisals and coping are more important than the emotions themselves in influencing perceptions of robots in the healthcare domain. Moreover, results highlight that there is a clear difference between media representations of robots and actual real-life encounters with physically present robots. Methodological considerations of the studies reported in this dissertation are also discussed, including both limitations and strengths of the reported studies. Finally, we provide ample suggestions for future research.

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