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

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Chapter 2

Belief in emotional coping ability affects what you see in a robot, not the emotions as such

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Abstract

Pressure on (future) healthcare systems may be relieved by technological solutions such as social robots. Most research on social robots focuses on the effects that robots may have on users' emotions *after* interacting with the robot. The current study, however, aimed at exploring how users' emotions *prior* to interacting with a robot may affect perceptions thereof. Many healthcare situations are emotionally demanding and previous research showed that emotions can influence perceptions and judgments. Therefore, we studied emotional effects on users' perceptions of healthcare robots based on two theoretical frameworks: a broaden-and-build, valence-based approach (Fredrickson, 1998; 2001), and an appraisal-tendencies approach (Lerner & Keltner, 2000; 2001). Different emotional states (various negative and positive ones) were induced in participants (*N*=184) in a between-subjects experiment. They were presented with a healthcare robot as described in a newspaper article. Measures included emotional appraisals and perceptions of the robot. Results appeared to show that the emotional valence did not directly influence the perceptions of the robot, but rather indirect effects seemed to occur. Supporting appraisal-tendencies theorizing, the emotions appeared to affect perceptions via emotional appraisals, particularly the appraisal of coping potential. Results suggested that coping potential was positively related to perceptions of the healthcare robot. Thus, emotions *indirectly* appeared to influence perceptions of a healthcare robot via the appraisal of coping potential.

Belief in emotional coping ability affects what you see in a robot, not the emotions as such

Due to aging populations worldwide, rising pressures on healthcare increase the need for technological innovation to support healthcare practices (World Health Organization, [WHO], 2012). Apart from the development of instrumental technologies such as patient lifts and CO_2 detectors, technologies are now being developed to support *social* aspects of healthcare. For example, virtual agents are used as depression therapists (Pontier & Siddiqui, 2008) and the Paro robot is successful in comforting elderly people suffering from dementia (e.g., Wada & Shibata, 2008). In general, social technologies attempt to support and motivate people and provide more autonomy to users or to relieve loneliness (e.g., Van Kemenade, Konijn, & Hoorn, 2015). Social robots, for instance, may remind people to take their medication, encourage physical exercise, keep people company, or enable users to connect to other people via audio or video (see Broadbent, 2017 for an overview of current applications of robots and research on human-robot interaction).

However, many people are quite skeptical or even fearful of robots, as evidenced by robots that rival humans in Sci-Fi movies such as “I, Robot” and underscored by scientific measures such as the “Robot Anxiety Scale” (Nomura, Suzuki, Kanda, & Kato, 2006). Because currently, users can hardly imagine what a social robot is and what it could do for them, they rely on Sci-Fi movies, newspaper articles, and other media. Hence, it makes sense to look for the boundaries between HCI and (media) psychology to develop theory on novices to robotics before robots are deployed in concrete user communities of patients and caregivers. If they merely provoke negative emotions, robots will not land in the care domain, or service professions more in general. In doing so, we should not merely study the characteristics or appearances of the robot, but also those of the potential users, particularly their emotional perceptions of the ‘scary’ robots that enter their homes. There is quite some research on the effects of robot characteristics on user cognitions and emotions. For instance, robot Paro, a furry, seal-like robot, was found to induce positive affect in healthy older adults (McGlynn, Kemple, Mitzner, King, & Rogers, 2017), reduce loneliness in rest home residents (Robinson, MacDonald, Kerse, & Broadbent, 2013), and reduce agitation and depression amongst dementia patients (Jøranson, Pedersen, Rokstad, &

Ihlebæk, 2015). However, little research has been done on the effects of already existing or *prior* user emotions on perceptions of these robots (Broadbent, Stafford, & MacDonald, 2009) whereas previous research showed that already existing feelings and emotions may influence whether people trust robots and how they perceive them (Broadbent, Kuo, Lee, Rabindran, Kerse, Stafford, & MacDonald, 2010). Trust and perceptions in turn influence the extent to which people accept robots. Furthermore, hedonic motivation (i.e., enjoying the use of technology), performance expectancy, effort expectancy, and opinions of people in one's environment also influence acceptance (cf. UTAUT, Venkatesh, Thong, & Xu, 2012). Thus, people's prior attitudes and feelings about social robots, before actually interacting with them, are of utmost importance for the introduction of robots in healthcare settings.

Social robots may thus seem supportive for health-related issues, but it is not so clear *why* social robots are (or are not) beneficial. Most studies on social robots in care focus on practical or therapeutic effects but are theoretically underdeveloped, which is understandable given the state of the art (e.g., Shibata & Wada, 2011). Different fields have found a variety of effects of robots in healthcare, such as psychological effects on relaxation and mood management, physiological effects on exercise and physical condition, and psychosocial effects on social support (Broekens, Heerink, Rosendal, 2009; Wada, Shibata, Saito, & Tanie, 2004). Social robots can be helpful in situations of stress, anxiety, and depression (e.g., Robinson et al., 2013), particularly in the case of lonesome and demented elderly (Kachouie, Sedighadeli, Khosla, Chu, 2014). For example, Sumioka, Nakae, Kanai, and Ishiguro (2013) measured a significant decrease in cortisol levels when older users interacted with a cuddly social robot compared to handling a mobile phone.

Most people in need of healthcare experience intense emotions, such as anxiously awaiting a diagnosis (e.g., Pineault, 2007), fear or anxiety for surgery or anesthesia (e.g., Mavridou, Dimitriou, Manataki, Arnaoutoglou, Papadopoulos, 2013), or depression due to enduring pain (e.g., Knotkova, Clark, Mokrejs, Padour, Kuhl, 2004). Meta-analyses and reviews from the field of emotion psychology consistently showed that intense emotional states can influence perceptions and judgments that are not related to the prior emotional situation per se (e.g., Angie, Connelly, Waples, & Kligyte, 2011; Blanchette & Richards, 2010; Lench, Flores, & Bench, 2011). It is thus quite likely that people's perceptions and acceptance of social robots are influenced by the emotions they experience before actually encountering a robot. Therefore, this study aimed to provide an exploration of the influence of emotions on their perceptions of such robots, at the same time trying to bridge the gap between the fields of HCI/HRI, media psychology, and emotion psychology.

In emotion psychology, two dominant theories exist about the nature of emotions that lead to rival hypotheses about the influence of emotional states on perceptions. Yet, the literature is unclear which of these theoretical approaches applies under which conditions. Furthermore, most research on social robots focuses on the effect that robots have on the emotions that people have *after* interacting with the robot, whereas the current study aims to explore how emotions may influence perceptions of the robot even *prior* to such interactions. In other words, “how do (prior) emotional states affect perceptions of a healthcare robot, particularly when people have nothing more to go on than a newspaper article?” This is important as it may have far reaching consequences for the way social robots are presented in the media and the acceptance and usage of robots in the long run. Perhaps it may be beneficial in the future to ensure that (potential) users are in a certain mood before interacting with a robot, or to have the robot anticipate the user’s mood state. To explore this question about the influence of (prior) user emotions, we tested two rival hypotheses about the effects of emotion – explained next.

How emotions influence perceptions: valence vs. appraisals

A large body of emotion literature suggests that emotions influence decision-making (Angie et al., 2011), attitudes, and perceptions (Lench et al., 2011). There is, however, some disagreement in the literature as to *how* emotions actually influence (unrelated) perceptions. This disagreement is based on beliefs about the nature of emotions. One theoretical perspective views valence as the most important aspect of emotion, suggesting that the different effects of emotions on (unrelated) perceptions (such as judgments, information processing, and memory) are explained by differences between negative and positive emotions (see Schwarz & Clore, 1996 for an overview). The other perspective views emotions as the outcome of a series of appraisals about the situation that causes the emotion, and (some of) these appraisals in turn may influence perceptions of a different, unrelated situation (Lerner & Keltner, 2000; 2001). Both perspectives are discussed in more detail hereafter.

The valence-based approach suggests that an emotion has either a positive or a negative valence. According to this approach, positive emotions will transfer to unrelated perceptions in a positive way and thus positively influence the unrelated situation, whereas negative emotions do the opposite (e.g., Clore & Huntsinger, 2007). Broaden-and-build (Fredrickson, 1998; 2001) is one of the theories that explains how positive and negative emotions may have a different influence.

The broaden-and-build theory asserts that positive and negative emotions lead to the widening or narrowing of worldviews. Fredrickson and Branigan (2005) explain that negative emotions are functional in that they narrow one’s focus to the issue at hand. For instance, if confronted with a wild animal such as a tiger, the feeling of anxiety is functional for undertaking action (e.g., by fleeing, or freezing and ‘playing dead’). Negative emotions narrow one’s worldview and repertoire of available thoughts and actions – for instance by only seeing the tiger and nothing else in the scene, and only being able to think of 1 or 2 actions to perform in that situation. Positive emotions, Fredrickson (1998; 2001) argues, do exactly the opposite: They make that people are more attentive of their environment and that they see more possibilities for action within the environment. Thus, positive emotions broaden one’s worldview and thought-action repertoire. Empirical evidence supports this: Positive affect leads, among others, to more leniency in making cognitive associations and categorizations (Isen, Johnson, Mertz, & Robinson, 1985; Murray, Sujan, Hirt, & Sujan, 1990) and more creativity (Davis, 2009; Fredrickson, 1998) compared to neutral or negative affect.

Because of this broadening of the thought-action repertoire, we can expect that prior emotions of positive valence may lead people to see more possibilities for using a robot (i.e., affordances), whereas people in negative emotional states may see fewer possibilities for using a robot. Thus, following the broaden-and-build theory, we predict that people in a positive emotional state see more possibilities in a robot and consequently perceive it more positively than people in a negative emotional state, whom are probably more focused on the situation that causes their negative emotion. Thus, emotional valence is expected to directly influence perceptions of a robot.

The appraisal-based approach, on the other hand, assumes that emotions differ from one another, not only in terms of valence, but also in terms of the (other) appraisals associated with each of those emotions (Smith & Ellsworth, 1985). According to this approach, every emotional situation is characterized by a series of situational appraisals (such as valence, agency, and coping potential) and each emotion consists of a unique set of situational appraisals (Frijda, 2007; Roseman & Smith, 2001). For instance, sadness is characterized by negative valence, situational agency, and medium coping potential, whereas happiness is associated with positive valence, human agency, and high coping potential (Ellsworth & Scherer, 2003; Smith & Ellsworth, 1985). Thus, instead of only distinguishing emotions based on positive or negative valence, the appraisal-based approach recognizes different emotions as distinct units with a unique pattern of associated appraisals.

Based on the idea that every emotion has a unique appraisal pattern, Lerner and Keltner (2000; 2001) developed the appraisal-tendency framework. This framework assumes that the differences in appraisals between different emotions are the basis for different effects of emotions on (unrelated) perceptions. For example, Lerner and Keltner (2000) explain that anger and fear differ from each other on the appraisals of certainty and control: Fear is characterized by high uncertainty and high situational agency (i.e., low self-agency), whereas anger is characterized by high certainty and high self-agency. The appraisal-tendency framework further predicts that these appraisals can transfer to unrelated situations and thus influence perceptions. For instance, for fearful people this means that future situations are more likely to be appraised as uncertain and beyond personal control, whereas angry people are more likely to feel they have control over and are certain about future situations. Research supports this view: Fearful people see future (unrelated) situations as more risky and uncertain and consequently assess them more pessimistically, whereas angry people perceive less risk and uncertainty and thus are more optimistic about future situations (Lerner & Keltner, 2000; 2001). The appraisal-tendency framework thus asserts that emotion influences judgment or perception via differences in appraisal patterns.

For the current study, we identified patient emotions that are often encountered in a diversity of healthcare situations (e.g., Olsson, Bond, Johnson, Forer, Boyce, & Sawyer, 2003). From the list of emotions, we chose four emotions for our study that differed on appraisal dimensions such as valence, certainty, coping potential, attentional activity, anticipated effort, agency, control, and novelty (Ellsworth & Scherer, 2003; Scherer, 1993; Smith & Ellsworth, 1985). These four emotions are happiness, hope, frustration, and sadness. Happiness, firstly, is characterized by appraisals of positive valence, low anticipated effort, goal conduciveness, high self-agency, high coping potential, and high intensity. Secondly, hope is characterized by positive valence, potential goal conduciveness, high situational agency, low self-agency, and moderate intensity. Thirdly, frustration is characterized by negative valence, goal obstruction, high situational agency, high coping potential, and high intensity. Finally, sadness is characterized by negative valence, goal obstruction, situational/other-agency[1], and medium coping potential. Based on the appraisal-tendency framework, we would expect that differences between the appraisal patterns associated with these emotions can explain differences in the effects of the different emotions on judgments and perceptions. Or, in other words, these appraisals would transfer to future situations, such as perceptions of a healthcare robot.

Thus, the broaden-and-build theory and the appraisal-tendency framework are two different ways to approach emotions. From these frameworks, two different (exploratory) hypotheses can be formulated about the influence of emotions on perceptions of a healthcare robot. In the broaden-and-build perspective, valence is the factor that explains differential effects of emotions on perceptions. Thus, the hypothesis would be that positive emotions (happiness and hope) lead to more positive perceptions of a healthcare robot than negative emotions (frustration and sadness) (H1). The appraisal-tendency framework on the other hand asserts that emotions can influence perceptions of future situations via the appraisal differences between emotions. If two emotions differ on the appraisal of certainty, then this (un)certainty is expected to influence perceptions of a future situation and can thus cause different effects for the two different emotions. Valence is but one appraisal dimension, and other appraisal dimensions (such as certainty, attentional activity, and coping potential) can also cause differences between emotions (as long as the appraisals on that dimension differ between these emotions). Because we included emotions in the current study that differ on some dimensions but not on others (e.g., the appraised valence does not differ between happiness and hope, but the appraisal of agency and intensity do), we hypothesized that differences in appraisals (beyond valence) influence perceptions of a healthcare robot (H2).

[1] Even though Smith & Ellsworth (1985) suggest that sadness is characterized by high situational agency, other researchers claim that sadness is open in terms of agency (i.e., not clearly situational or human agency; Ellsworth & Scherer, 2003; Roseman, 1991).

Method

Participants and design

Participants (N = 184; M_{age} = 33.03, SD_{age} = 14.74, 66.8% female) were randomly distributed over five conditions (emotional state: happiness vs. hope vs. sadness vs. frustration vs. neutral) of a between-subjects online experiment. Participants were recruited via snowball sampling through e-mail and social media (n = 92, voluntary participation), via a first-year student pool (n = 52, who received course credit for participation), and via general student mailing lists (n = 40, voluntary participation). These three sub samples differed significantly from each other in terms of age and education: Participants recruited via snowball sampling were significantly older (M = 43.27, SD = 13.38; F(2,179) = 89.78, p <.001, η_p^2 = .50) and lower educated (24.18% attended university; χ^2(12) = 88.25, p < .001) compared to participants from the first year student pool (M = 20.49, SD = 1.87, 100% attended university) and participants recruited via the general mailing lists (M = 25.73, SD = 9.26, 100% attended university). However, the participants from these different sub samples were evenly distributed across the different conditions. Hence, we found no differences between participants in the different conditions in terms of age, level of education, how they were recruited, and gender.

Manipulation

The four experimental emotions were all induced using the same recall procedure (cf. Lerner & Keltner, 2001; Small & Lerner, 2008). Participants were asked to recall a specific instance of illness in their past in which they experienced the emotion as indicated (e.g., “Try to recall one specific situation in which you felt ill or needed care, and you felt very frustrated/happy/hopeful/sad”). To aid recall, participants were asked to remember the situation as vividly as possible through questions such as “Why did that situation make you feel frustrated?” and “How did it feel to be frustrated?” Participants were instructed to take some time to remember the situation vividly and then asked to briefly describe the situation in writing. In the neutral condition, participants were asked to recall a specific situation in which they felt a mild cold or sore throat coming up, which was gone again the next day. Similar to the experimental conditions, some questions were asked to aid recall, but these were more focused on practical matters (e.g., “What did you do that day?”) and less on feelings experienced in the situation to prevent the induction of specific emotional responses. We hoped to minimize emotional responses of participants in the neutral condition by focusing on a relative minor health issue, yet we realized that probably some slight negative emotions would be experienced by people in this condition due to the reference to the cold and sore throat.

Procedure

Participants were invited to an online study about opinions and experiences with illness and healthcare. Most studies on the influence of emotions on (unrelated) judgments or decisions present the emotion induction and outcome measures as two separate studies to the participants to prevent participants from guessing the study’s purpose (e.g., Lerner & Keltner, 2000; Dunn & Schweitzer, 2005; Lench & Levine, 2005). Because we used an online study instead of a lab study, we decided not to present our study as two separate studies because of the risk of attrition after the emotion induction. Instead, we decided to present the study as one study that had two distinct parts, which were both closely related to healthcare. By doing so, we aimed to prevent attrition and that possible demand effects (i.e., participants guessing the purpose of the study) would obscure any genuine effects of the emotion inductions (Lench et al., 2011; Westermann, Spies, Stahl, & Hesse, 1996). Participants’ feedback at the end of the study did not show awareness of the study’s purpose.

For the first part of the study, participants were told they would answer questions about the role of emotions in illness and healthcare situations and about recalling such emotions. In fact, this part contained the emotion induction (see ‘manipulation’), the appraisal dimension scales (presented as queries to help remember the emotional situation), and two manipulation checks (presented as measurements to assess reactivation of the recalled emotion).

For the next part of the study, participants were told that the questions assessed their opinions about the future of healthcare. At the beginning of this part, participants were asked to read a (fictitious) newspaper article about Alice, a healthcare robot (see Appendix 1). Even though the newspaper article was fictitious, robot Alice was not: Alice is a humanoid robot manufactured by Robokind. In the article, some of Alice's potential benefits were highlighted, comprising both practical and social tasks (e.g., making beds, monitoring, reminding people to take medication, having a chat), even though Alice was physically not capable to perform all the tasks that were described in the article. Subsequent questions were presented as assessing participants' opinions about the future of healthcare, particularly the role of robots. These questions actually assessed participants' perceptions about Alice (see 'Measures' below).

Finally, participants provided demographic information and were invited to comment on the study and the study's topic (i.e., emotions in healthcare and the future of healthcare), after which they were thanked, debriefed, and dismissed.

Measures

We performed reliability analyses using Spearman-Brown's coefficient for 2-item scales (cf. Eisinga, Te Grotenhuis, & Pelzer, 2012) and Cronbach's alpha for scales consisting of 3 or more items in combination with Principal Components Analyses (PCA) to check the coherence of our scales. Results of PCAs are discussed only where items were discarded.

Manipulation checks. To check whether the manipulation (i.e., the emotion induction) was successful, we assessed to what extent people experienced a number of emotions after the manipulation (frustration, sadness, hope, happiness, and filler items such as anxiety, pride, and enthusiasm) on 5-point rating scales (1 = not at all, to 5 = very strongly). We used 5 items to check frustration[2] (e.g., frustrated, irritated), which formed a reliable scale (Cronbach's $\alpha = .90$). Sadness was measured using 2 items (sad, blue), which had high internal consistency ($r_{\text{Spearman-Brown}} = .92$). Happiness was also assessed using 2 items (happy, joyful) and had high internal consistency ($r_{\text{Spearman-Brown}} = .92$). The 2 items for hope (hopeful and desperate [reverse-coded]) did not correlate significantly, thus we used a single-item measure (hopeful) to check the manipulation of hope.

Furthermore, we assessed *intensity* of the recalled emotion (not for the neutral condition) on a 10-point rating scale. As part of the emotion-induction procedure,

[2] Frustration was measured using 5 items because it was harder to find appropriate items for this scale in comparison to the other scales. Therefore, we created a longer scale to be able to lose the poorest items.

participants were asked to indicate to what extent they experienced the recalled emotion, with 1 indicating the lowest and 10 the highest intensity level.

Appraisal dimensions. From the literature, we distilled 11 appraisal dimensions. Because we wanted to explore effects of appraisals and we had no theoretical grounds for excluding any of the dimensions, we maintained all 11. We used 11 scales consisting of 2 to 4 statements about the situation that the participants had recalled during the emotion induction procedure. Participants indicated the extent to which they agreed with each of the 27 statements (1 = completely disagree, to 5 = completely agree), presented to respondents in random order. We used positively and negatively worded items in each scale, so items were reverse-coded where needed.

Valence, whether the emotional situation was positive or negative, was measured using 2 items (e.g., "I thought the situation was enjoyable"; Smith & Ellsworth, 1985). These items formed a reliable scale for group comparisons ($r_{\text{Spearman-Brown}} = .62$).

Anticipated effort of the emotional situation was assessed with 2 items (Smith & Ellsworth, 1985), for instance: "The situation required a lot of effort (mental and/or physical)". Together, the items formed a reliable scale ($r_{\text{Spearman-Brown}} = .70$).

Attentional activity – whether the emotional situation attracted attention towards that situation or diverted attention away from it – was measured with 2 items (Smith & Ellsworth, 1985). The items specifically mentioned the induced emotion and were therefore not presented to participants in the neutral condition. The 2 items ("the situation that made me feel frustrated/sad/happy/hopeful made me focus my attention elsewhere" and "I wanted to investigate the situation that made me feel frustrated/sad/happy/hopeful further") were found to be uncorrelated ($r_{\text{Spearman-Brown}} = .31$) and thus were used separately in further analyses.

Goal conduciveness, the extent to which the situation helped the participant reach his/her goal, was assessed by means of 2 items ("The situation was conducive to achieving my goals" and "The situation hindered me in achieving my goals" [reverse-coded]; cf. Scherer, 1993; Smith & Ellsworth, 1985). The items did not significantly correlate with one another ($r_{\text{Spearman-Brown}} = .27$), so we used the 2 items separately in further analyses.

Legitimacy, whether the situation was fair and deserved, was measured with 2 items (Roseman, Antoniou, Jose, 1996; Tong, 2010). Participants were asked to respond to statements such as: “I felt I had deserved this situation”. A mean index was calculated from the 2 items ($r_{\text{Spearman-Brown}}$ = .76).

Agency measured the extent to which the situation was attributed to circumstances, to someone other than the self, or to the self (covering the concepts of agency, control, responsibility, and power from Ellsworth & Scherer, 2003; Ellsworth & Smith, 1988a; Smith & Ellsworth, 1985). We assessed human agency, non-human agency, other-agency, and self-agency using 4 items, for instance: “I or someone else had caused the situation to be as it was” (human agency). Based on results from PCA and reliability analyses, we decided to use the 4 items separately in further analyses.

Certainty was measured with 3 items (cf. Smith & Ellsworth, 1985) assessing certainty about the situation and how it would end (e.g., “The consequences of the situation were predictable”). However, based on results of PCAs and reliability analyses (i.e., Cronbach’s α = .51) we used the 3 items separately in the analyses.

Situation intensity was measured using 2 items, to check whether indeed some of the emotional situations were experienced more intensely than others, for example: “I found the situation intense”. The 2 items were collapsed into a mean index ($r_{\text{Spearman-Brown}}$ = .64).

Urgency used 2 items to assess whether urgent action was required in the situation (e.g., “the situation required that action should be taken quickly”, cf. Scherer, 1993) and whether inaction would make the situation worse (Ellsworth & Scherer, 2003). Together these items formed a reliable scale for group comparisons ($r_{\text{Spearman-Brown}}$ = .64).

Novelty was assessed with 4 items measuring whether the situation was new, unfamiliar, and unexpected (e.g., “I had been in a similar situation before”; Ellsworth & Scherer, 1993; Roseman et al., 1996). The 4 items formed a reliable scale (Cronbach’s α = .71).

Coping potential is about how people think they have the skills and resources to deal with their emotions in a specific situation, regardless of *actual* ability to influence/control the situation (Ellsworth & Scherer, 2003). Two items assessed respondents’ thoughts about their potential ability to cope with the situation, for instance: “I knew how I could best deal with this situation”. The items were combined into a mean index ($r_{\text{Spearman-Brown}}$ = .60).

Perceptions of the robot. Perceptions of robot Alice were assessed by means of 7 concepts from the framework for Interactively Perceiving and Experiencing Fictional

Characters (I-PEFiC; e.g., Van Vugt, Hoorn, Konijn, & Veldhuis, 2009; based on the PEFiC framework for perceiving non-interactive characters; Konijn & Hoorn, 2005): ethics, affordances, relevance, valence, involvement, distance, and use intentions. Participants were asked to respond to 49 statements (based on Van Vugt, Hoorn, Konijn, & De Bie Dimitriadou, 2006) using 5-point rating scales (1 = totally disagree, to 5 = totally agree). Half of these items, except for the items of involvement and distance, were negatively-keyed and thus reverse-coded before analysis. See Table 1 for an overview of all items per scale (validity of these scales have been extensively tested and shown in previous research, e.g., Pontier & Siddiqui, 2008; Van Vugt et al., 2006; Van Vugt et al., 2009).

Perceived valence. The direction of valence when one would use the robot in the future (e.g., “I have positive expectations about this healthcare robot”) was assessed using 10 items, which together formed a reliable scale (Cronbach’s $\alpha = .90$).

Perceived affordances. Whether the robot was perceived as having helpful possibilities for action or not was assessed by means of 10 statements (e.g., “This healthcare robot is clumsy”). Together, these 10 items formed a reliable scale (Cronbach’s $\alpha = .86$).

Perceived relevance. User perceptions about the relevance of the robot for their personal life were assessed by means of 9 statements (e.g., “this healthcare robot is important to me”), which together formed a reliable scale (Cronbach’s $\alpha = .92$).

Perceived ethics. Perceptions of whether the robot was ethically good or bad were measured using 4 statements (e.g., “This healthcare robot is malevolent”). Based on the PCA, 2 items were dropped (see Table 1). A mean index was calculated from the 2 remaining items ($r_{\text{Spearman-Brown}} = .78$).

Perceived involvement. Friendly feelings towards the robot were measured using 4 items (e.g., “I feel involved with the healthcare robot”). These items showed good internal consistency and thus were collapsed into a mean index (Cronbach’s $\alpha = .74$).

Perceived distance. Cold feelings towards the robot were assessed by 4 items (e.g., “such a healthcare robot comes across as distant”) that showed good internal consistency (Cronbach’s $\alpha = .74$).

Perceived use intentions. The intention to learn more about the robot and to actually use it was assessed with 6 items (e.g., “I would use the healthcare robot”), which together formed a reliable scale (Cronbach’s $\alpha = .85$).

Table 1. Overview of the robot perception measures and their reliabilities

Scale	Items used in scale	Reliability[a]
Perceived valence	I… have positive expectations, expect it to be fun, am ready for it, expect it to turn out positively, am looking forward to it, have negative expectations[b], expect it to be annoying[b], foresee bad things[b], expect disappointment[b], dread it[b]	.90
Perceived affordances	The robot seems… intelligent, able, capable, skillful, handy, dumb[b], clumsy[b], incompetent[b], poor[b], awkward[b]	.86
Perceived relevance	The robot seems… important, valuable, useful, meaningful, irrelevant[b], insignificant[b], useless[b], unnecessary[b], pointless[b]	.92
Perceived ethics	The robot seems… malevolent, mean, reliable[c], trustworthy[c]	.78
Perceived involvement	The robot… gives me a good feeling, seems warm, seems nice, I feel connected to it	.74
Perceived distance	The robot… gives me a bad feeling, comes across as distant, seems cold, seems irritating	.74
Perceived use intentions	I would… use it, send it away[b], let it help me, ignore it[b], want to read the rest of the newspaper article, skip the rest of the article[b]	.85

[a] Reported values are Cronbach's alpha for all scales except perceived ethics (which used Spearman-Brown's coefficient).
[b] Item was reverse-coded.
[c] Item dropped from the scale based on results of PCA and reliability analysis.

Results

Manipulation checks

To assess the effectiveness of the emotion induction procedure, we checked participants' emotional states in two ways: Verbally and statistically. First, we checked whether the participants' verbal recall reports were in line with the assigned emotion, which was the case for all participants. Next, we performed statistical analyses to check whether 1) the intended emotion was indeed induced in each condition (and not contaminated with other emotional states), 2) the appraised valence of each induced emotion was in the expected direction, and 3) the induced emotions were experienced as equally intense.

To check the manipulation of emotional state, we performed a MANOVA[3] with the condition as independent variable and the emotion scales (frustration, sadness, happiness, and the individual item for hope) as the dependents. Multivariate results showed that there were indeed differences between the conditions, Wilk's $\lambda = .51$, $F(20,581.359) = 6.58$, $p < .001$, $\eta_p^2 = .16$, and univariate tests confirmed that the intended emotions were

[3] We chose to perform MANOVA instead of repeated ANOVA analyses because the emotion scales used as dependent variables were found to be correlated (cf. Field, 2009).

induced (all *F*'s (4,179) > 5, all *p*'s ≤ .001, and η_p^2 ranged between .10 and .21). Pairwise comparisons[4] showed a similar pattern, with the exception of hope (see Table 2). Participants in the hope condition turned out to be fairly sad (i.e., not significantly less sad than sad participants) and less hopeful than happy participants.

Table 2. Means (*M*) and standard deviations (*SD*) of scores on each of the emotion manipulation checks [a]

	Frustration condition		**Sadness condition**		**Neutral condition**		**Happiness condition**		**Hopeful condition**	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Frustration (scale)	2.86	1.22	2.17	1.13	1.52	.69	1.64	.77	1.87	.77
Sadness (scale)	2.16	1.17	2.37	1.26	1.20	.49	1.56	.68	2.03	1.09
Happiness (scale)	1.56	.99	1.51	.85	1.69	.97	2.99	1.32	2.12	1.23
Hope (1 item)	1.74	1.04	2.00	1.19	1.82	1.11	3.03	1.30	2.91	1.33

[a] Participants in the frustration condition were significantly more frustrated than participants in the other conditions (p's < .05). Participants in the sad conditions were significantly sadder than happy and neutral participants (p's < .001) but not more than frustrated and hopeful participants (ns). Participants in the happy condition were happier than participants in the other conditions (p's <.02). Participants in the hope condition were more hopeful than participants in the neutral, frustrated, and sad conditions (p's < .02), but not more than those in the happy condition (ns).

Next, we checked whether the positive and negative emotions indeed differed in terms of appraised valence of the situation. Results of an ANOVA with the emotion condition as independent and the appraisal of valence as the dependent variable showed that the emotions differed in terms of appraised valence, $F(4,179) = 13.31$, $p < .001$, $\eta_p^2 = .23$. Pairwise comparisons showed that this effect could be attributed to a significantly more positive valence among happy participants ($M = 2.81$, $SD = 1.23$) compared to the hopeful ($M = 2.00$, $SD = 1.18$), neutral ($M = 1.88$, $SD = .72$), frustrated ($M = 1.41$, $SD = .54$), and sad participants ($M = 1.44$, $SD = .79$; all *p*'s < .01). None of the other pairs were significant. Given the means, hope and neutral did not differ too much, and hope thus was not as clearly a positive emotion as intended. Therefore, we did not include the hope condition in further analyses.

Finally, we performed an ANOVA to check for differences between the emotional conditions (i.e., excluding the neutral condition[5]) on the *intensity of recall* for the intended emotion. Results showed that emotional intensity differed between the conditions, $F(3,136) = 3.62$, $p = .02$, $\eta_p^2 = .07$. Pairwise comparisons showed that this main effect was caused by

[4] We applied Bonferroni-correction to all pairwise comparisons reported in the Results section.
[5] Intensity of emotion recall was not measured in the neutral condition, as it was part of the emotion induction procedure for the emotion conditions (see 'Method').

a significant difference between the intensity of recall of frustration (*M* = 7.77, *SD* = 1.77) and happiness (*M* = 6.00, *SD* = 2.51, $p = .02$). None of the other comparisons were significant.

Testing hypotheses

The exploratory nature of the current study cannot meet the high standards of well-developed experiments in laboratory settings, which led us to set a less stringent alpha level of 90% for the statistical analyses to increase power and still balance the risk of Type I and Type II errors (Lipsey & Hurley, 2009).

Testing the effects of valence. The first hypothesis, derived from the broaden-and-build theory, predicted that emotions with positive valence would lead to more positive perceptions about the healthcare robot than emotions with negative valence. We tested this in a one-way MANOVA (to control for the interrelatedness of many of the perception measures, cf. Ellsworth & Smith, 1988a), in which we compared emotions with positive valence (i.e., happiness) to emotions with negative valence (i.e., frustration and sadness together) and used the 7 perception measures as dependent variables. Results showed that there were no significant multivariate (Wilk's $\lambda = .93$, $F(7,98) = 1.00$, $p = .44$) and univariate differences between the conditions (all *F*'s < 3, all *ns*). Thus, we found no differences between the (induced) positive and negative valence of emotions on perceptions of the robot.

Additional regression analyses with the *appraised* valence[6] of the emotional situation[7] as independent and perception measures as dependent variables, showed there was only a significant negative effect of appraised valence on experienced distance towards the robot ($t(104) = -3.04$, $p < .01$, $b(SE_b) = -.22$ (.07), $\beta = -.29$). Thus, the more positively people appraised their situation, the less distance they felt towards the robot. None of the other perception measures were influenced by the appraised valence of the situation.

Testing the effects of appraisals. The second hypothesis, based on the appraisal-tendency framework, predicted that differences in appraisals between emotions may cause

[6] Appraised valence was reported by the participants themselves, instead of being based on the literature (as was the case in the previous analysis).
[7] Earlier analyses (see 'Manipulation checks') showed that happy situations were appraised as having a more positive valence than frustrating and sad situations.

differences in perceptions. To test this, we used a two-step approach. First, we tested for differences between the emotional conditions on the appraisal dimensions. Because most appraisals were correlated, we performed a one-way MANOVA with the emotion conditions as independent and the appraisal dimensions as dependent variables. For the second step, we used the appraisals as predictors in a series of regression analyses to test whether the appraisals influenced perceptions about the robot. Results are discussed in detail below.

In the first step, we found a significant multivariate effect of condition on appraisal dimensions, Wilk's $\lambda = .41$, $F(36,172) = 2.71$, $p < .001$, $\eta_p^2 = .36$. Univariate results showed that the emotion conditions differed in terms of appraisals of valence (cf. manipulation checks, $F(2,103) = 27.56$, $p < .001$, $\eta_p^2 = .35$), coping potential ($F(2,103) = 4.68$, $p = .01$, $\eta_p^2 = .08$), anticipated effort ($F(2,103) = 10.92$, $p < .001$, $\eta_p^2 = .18$), legitimacy/fairness ($F(2,103) = 16.65$, $p < .001$, $\eta_p^2 = .24$), and situation intensity ($F(2,103) = 4.00$, $p = .02$, $\eta_p^2 = .07$). For the single items that assessed goal conduciveness, we found that the manipulated emotions differed on goal conduciveness ($F(2,103) = 10.52$, $p < .001$, $\eta_p^2 = .17$) and goal hindrance (recoded) ($F(2,103) = 2.48$, $p = .089$, $\eta_p^2 = .05$). For the appraisal of attentional activity, the single item for attention diversion (recoded) was significantly different between emotion conditions ($F(2,103) = 8.40$, $p < .001$, $\eta_p^2 = .14$), whereas the single item attention focus was not ($F < 1$, *ns*).

Table 3. Means (*M*) and standard deviations (*SD*) of (significantly different) scores on appraisal measures

	Frustration condition		**Sadness condition**		**Happiness condition**	
	M	*SD*	*M*	*SD*	*M*	*SD*
Valence	1.41	.54	1.44	.79	2.81	1.23
Coping potential	2.63	.97	2.53	1.12	3.22	1.00
Anticipated effort	2.27	1.02	1.83	.86	2.92	1.07
Legitimacy/fairness	1.40	.69	1.70	1.00	2.76	1.34
Intensity	3.59	1.10	3.84	.90	3.21	.84
Goal conduciveness	1.40	.65	1.66	.97	2.47	1.34
Goal hindrance[a]	2.80	1.41	2.54	1.38	3.28	1.45
Attention diversion[a]	3.49	1.34	3.57	1.27	2.44	1.27

[a] Items were reverse-coded

Pairwise comparisons confirmed that happy participants appraised their situation as having more positive valence than frustrated and sad participants did (both *p*'s < .001, see Table 3). Furthermore, happy participants appraised their situation as more legitimate, more goal conducive, less diverting attention away from the situation, and requiring less effort compared to sad and frustrated participants (all p's $< .03$). Additionally, happy participants appraised their emotional situation as easier to cope with than sad ($p = .02$) and frustrated participants ($p = .052$). For goal hindrance, a significant difference was found between the happy and sad participants ($p = .09$). Finally, sad participants appraised their situation as significantly more intense than happy participants ($p = .02$).

The next step in testing the indirect effect of emotions on perceptions about the robot via the emotional appraisals was to test the effects of appraisals on the perception measures. We used the appraisal measures as independent variables in a series of linear regression analyses with the perception measures as dependents. For the sake of clarity, only appraisal dimensions that are both significant predictors as well as different between emotional states (in step 1) will be discussed below.

Valence as an appraisal turned out to be a positive predictor of involvement with the robot, as a more positive appraisal of the valence of the emotional situation was associated with a higher involvement with the robot, $t(87) = 1.81$, $p = .07$, $b(SE_b) = .17$ $(.09)$, $\beta = .26$.

Coping potential was found to be a significant positive predictor of perceived relevance ($t(87) = 2.01$, $p = .047$, $b(SE_b) = .18(.09)$, $\beta = .27$), of perceived valence of the robot ($t(87) = 2.27$, $p = .03$, $b(SE_b) = .22$ $(.10)$, $\beta = .31$), of perceived affordances of the robot ($t(87) = 1.67$, $p < .10$, $b(SE_b) = .14(.09)$, $\beta = .23$), and of the participant's intention to use the robot ($t(87) = 2.41$, $p = .02$, $b(SE_b) = .26$ $(.11)$, $\beta = .31$). Thus, the more participants felt they had the ability to cope with the emotional situation they recalled, the more positive perceptions they had about the robot's relevance, valence, affordances, and their own intentions to use the robot.

Anticipated effort was found to have a negative effect on relevance, meaning that the more effort participants anticipated, the less relevant they perceived the robot to be for them, $t(87) =-1.70$, $p = .09$, $b(SE_b) = -.17(.10)$, $\beta = -.26$.

Intensity was found to have a negative effect on perceived involvement, suggesting that the more intense the recalled emotional situation was, the less involved people felt with the robot, $t(87) = -.23$, $p = .07$, $b(SE_b) = -.17$ $(.10)$, $\beta = -.23$.

Finally, *goal hindrance (recoded;* i.e., whether the person's goals were not obstructed by the situation they were in) was found to be a positive predictor of perceived valence, $t(87) = 1.88$, $p = .06$, $b(SE_b) = .11$ $(.06)$, $\beta = .20$). Thus, the more participants felt their situation did *not* keep them from achieving their goals, the more positive expectations they had about the robot.

To summarize, H2 predicted that differences in appraisals between emotions (beyond valence) would lead to differences in perceptions about the robot. Results showed that the emotion conditions differed on several appraisals, and that five of these appraisals further influenced one or more robot perception measures. Thus, these results lend some support to our second hypothesis.

Additional mediation analyses

The results from the two-step approach above raised the question of possible mediation of appraised coping potential (which was the only appraisal that influenced multiple measures of robot perceptions). Therefore, we analyzed whether the appraisal of coping potential served as a mediator between the (manipulated) valence of the emotional state people were in and their perceptions of the robot. We tested this in a series of bootstrapped mediation analyses using the SPSS macro PROCESS (Hayes, 2013), in which we used the manipulated valence of emotional state (i.e., negative [sad and frustrated participants] vs. positive [happy participants]) as independent variable.

Results showed mediation effects of appraised coping potential that were statistically different from zero for almost all of the robot perception measures: for affordances, for relevance, for valence, for involvement, for distance, and for use intention (see Table 4 for an overview of results). We found no indirect effects of valence of emotional state on perceived ethics via appraised coping potential. Thus, results of the mediation analyses seem to suggest that the appraisal of coping potential may mediate the effect of the manipulated emotional valence on robot perceptions.

Table 4. Indirect (mediation) effects of coping potential on I-PEFiC measures[a]

	B	***SEb***	**95% *CI***	**B**	***SE*β**	**95% *CI***
Affordances	.10	.05	[.02, .21]	.07	.03	[.02, .15]
Relevance	.09	.05	[.02, .22]	.06	.03	[.01, .15]
Valence	.13	.06	[.03, .30]	.08	.04	[.02, .17]
Involvement	.10	.05	[.01, .22]	.06	.03	[.01, .14]
Distance	-.14	.07	[-.31, -.03]	.08	.04	[-.17, -.02]
Use Intention	.19	.08	[.07, .37]	.10	.04	[.04, .20]

[a] No indirect effect was found of emotional valence via coping potential on participants' perceptions of the robot's ethics

Discussion

In the current paper, we measured the effects of a participant's emotion prior to rating a healthcare robot presented in a news article as a – today – ecologically valid situation in which people have to come to terms with social robots entering their lives. These participants did not have any direct experience with robots quite like most of the prospect users won't. Hence, this study was an assessment of user emotions as well as an assessment of (the influence of user emotions on) perceptions of the robot.

Our general aim was to explore whether and how prior emotions influenced perceptions of (future) healthcare robots. Based on insights from the broaden-and-build theory (Fredrickson, 1998; 2001), we expected (H1) that emotional valence would transfer to perceptions about the robot as read in the news. However, our results did not seem to provide support for this hypothesis. Results appeared to show more support for H2, based on the appraisal-tendency framework (Lerner & Keltner, 2000; 2001). We found that happiness, frustration, and sadness differed from each other on appraisals of valence, coping potential, anticipated effort, legitimacy/fairness, intensity, goal conduciveness, and attention diversion. From those appraisals, valence, coping potential, anticipated effort, recoded goal hindrance, and intensity seemed to *also* have an influence on one or more of the robot perception measures. Happy participants appraised their situation more positively than sad and frustrated participants, and appraised valence was positively related to involvement with the robot. Sad participants appraised their situation as more intense than happy participants, and situation intensity was found to be negatively related to involvement with the robot. Happy participants anticipated less effort than frustrated and sad participants, and anticipated effort was found to have a negative relationship with the robot's perceived relevance. Finally, the appraised potential to cope with the emotional situation was higher among the happy participants than among sad and frustrated participants, and this appraisal of coping potential appeared to positively influence perceptions of the robot's affordances, relevance, valence, and use intentions.

These results, combined with the finding that appraised coping potential seemed to mediate the influence of (manipulated) emotional valence on robot perceptions, appear to show that particularly the appraisal of coping potential played an important role in influencing perceptions of the healthcare robot. Results seem to indicate that happy participants found it easier to cope with their emotional situation than sad and frustrated participants. Furthermore, the easier people thought they could cope with their emotional situations, the more positive they appeared to be about the robot's affordances, relevance, valence, and their own intentions to use a robot. Based on these results, we can only speculate about possible explanations for this effect. One possible explanation is that people who find it easier to cope with an emotional situation may have more cognitive space than people who find it harder to cope with an emotional situation. This explanation does appear similar to the broaden-and-build perspective, with the difference that it does not appear to be one's emotional valence but rather one's potential ability to cope with the situation that causes a broadening of the thought-action repertoire.

Further research is needed to replicate results and to determine *how* exactly (the appraisal of) coping potential may influence healthcare-robot perceptions. Pointers for future research can be found in the stress literature. Lazarus (2006), for instance, distinguishes between primary appraisals (i.e., is this situation relevant to me and my goals?) and secondary appraisals (i.e., can I cope with this situation, and if yes, how?). Because coping potential is part of the secondary appraisal process and seems to play such an important role in influencing perceptions of a healthcare robot, the secondary appraisal process seems worthwhile to investigate further in relation to healthcare robots.

The current study aims to answer a call for more research on the influence of emotions on the acceptance of healthcare robots (Broadbent et al., 2009). Broadbent and colleagues (2010) already showed that prior attitudes and positive emotions about robots influence how people perceive the quality of the interaction with a robot. The current study goes beyond that by showing that not only integral emotions but also incidental emotions (i.e., emotions not related to the robot) may (indirectly) influence people's perceptions of a healthcare robot, even when they read about it in the newspaper and have never interacted with a robot before. Furthermore, our results seem to suggest that this is true for discrete emotions whereas Broadbent and colleagues (2010) used general positive and negative affect. Nevertheless, these results suggest that emotions may play an important role in the shaping of robot perceptions and the acceptance thereof.

Another addition to the robot literature is the use of a framework for assessing perceptions of the robot (i.e., I-PEFiC; Van Vugt et al., 2009). Several studies in the field of robotics use aggregate measures of perceptions of the robot, referred to as quality of interaction (Broadbent et al., 2010) or attitude (Ellsworth & Smith, 1988b). In using the I-PEFiC framework, we recognize that robots are not only tools, but actual social agents whom we assess in similar ways as we would humans or avatars: We encode the robot's characteristics, compare them to our own goals, and respond appropriately. To do this idea justice, we measured perceptions based on several dimensions. As the results showed, some of the emotional appraisals influenced only one or two of these perception measures. Thus, it seems that different appraisals influence different perceptions about the robot, which we probably would have failed to detect had we used an aggregate perception measure.

Limitations

To manipulate emotion in the current study, a standard recall procedure was used (cf. Lerner & Keltner, 2001; Small & Lerner, 2008). This procedure was very successful for three of our emotional states. For the hope condition, however, the induction was less effective. Furthermore, we expected a slightly negative emotion for the neutral condition, yet results showed that this group scored quite low on *all* of the emotion measures (and not just the positive ones). In the hope condition, we asked participants to specifically remember a hopeful situation that was related to illness. In hindsight, however, hope is recognized as a mixed emotion: it is a so-called anticipatory emotion (Lazarus & Folkman, 1984) which has positive valence, is accompanied by many negative appraisals, and is future-focused (Ellsworth & Smith, 1988b; Tong, 2014) and thus the participants in this condition most likely recalled not only the positive aspects of the situation that we had hoped for. Future researchers that want to successfully manipulate hope are thus advised to focus on both the positive *and* negative aspects of this complex emotion.

A complication to the use of the recall procedure was the fact that the recalled emotional situations were likely resolved by the time participants were asked to recall them. Lerner and Keltner (2000) note that each emotion serves a specific goal, and that appraisal tendencies will cease to influence other situations once the emotion's goal is attained. Thus, goal-attainment is one of the boundary conditions for appraisal tendencies to occur. In using the recall procedure, these goals were perhaps already met by the time people recalled the emotional situation. This may also explain the relatively low effect sizes found for the different emotions (values ranged between .10 and .21). However, we deemed it important to induce personally relevant emotions related to illness as this was the field of application in the current study, which is one of the important strengths of the recall procedure. Since most other emotion induction procedures are not very personally relevant for participants, we challenge future researchers to find emotion induction procedures that are highly relevant as well as effective in inducing emotions.

If the participants' goals were indeed attained before the study, it means that participants may have already coped with the emotional situation that they recalled. As researchers have shown in a diversity of contexts (e.g., Folkman, Lazarus, Dunkel-Schetter, DeLongis, & Gruen, 1986; Lazarus, 2006; MacNeil, Esposito-Smythers, Mehlenbeck, Weismoore, 2012), secondary appraisals are related to the kinds of coping strategies that people use to actually deal with their emotional situation. Thus, the role that *actual* coping plays in the relationship between incidental emotions and perceptions of healthcare robots seems to be an important direction for future research.

Even though the results seem to suggest that valence did not influence perceptions of the robot directly, we need to be cautious in rejecting the valence-based hypothesis altogether. The results that the appraisals of coping potential, anticipated effort, valence, and intensity were different for happy participants compared to sad and frustrated participants appears to suggest that emotional valence may have *indirectly* influenced perceptions of the robot (i.e., mediated by appraisals). Because the hope induction was less successful, we only had one positive emotion to compare the negative emotions to. Comparing multiple discrete positive emotions to multiple discrete negative emotions in future studies would allow for better testing of the indirect pathways of the effects of valence on perceptions. Furthermore, this would allow to see whether the indirect effect that we appeared to have found in the current study can be replicated.

In terms of research design, the current study assessed the effects of emotions on perceptions of (future) healthcare robots as they were presented in a newspaper article. These perceptions were based on people's pre-existing knowledge about healthcare robots combined with the information they got about robot Alice in the newspaper article. Effects may, of course, be different when participants interact with an actual robot instead of reading about one. UTAUT for one thing expects that experience with technology is a strong moderator of use intentions and actual use (Venkatesh et al., 2012). Yet, people may not even come to experience a robot in real life if they already refused it based on the fact that they feel they cannot cope with their care situation. Their appraisals of potential to cope with an emotional situation may block out their willingness to use a healthcare robot at all, although it may deliver excellent service. Future research is needed to determine how long and strong such (potential) preoccupations last when people are offered the opportunity to have an actual interaction with a healthcare robot, and whether the current study's effects replicate when people are presented with a physical robot.

Finally, it is possible that we found relatively little effects and small effects sizes due to a relatively low statistical power. We had a relatively small sample considering the number of variables that were assessed. Because this was a first, exploratory study in this research area, we did not have a (theoretical) basis for excluding any variables. However, even though our results should be interpreted with caution, the results do provide some interesting pointers for future studies into the effects of incidental emotions on people's perceptions of healthcare robots. Most important in this sense would be the role of coping potential, which appeared to be an important factor in the current study. Apart from attempting to replicate the current study's results, it may be worthwhile to aim to replicate results while controlling for variables that have been recognized earlier as factors that are important in influencing people's perceptions of robots (such as age, gender, culture, cognitive ability, and experience with technology; see Broadbent et al., 2009 for a review).

In all, our findings seem to indicate that incidental emotions do not have a direct but rather appear to have an *indirect* influence on people's perceptions of healthcare robots as presented in the media. Emotions appear to influence perceptions of healthcare robots *indirectly* via appraised coping potential. Results emphasize the importance of people's feelings about their abilities and resources for coping with their emotion (i.e., their appraised coping potential) in influencing their perceptions of healthcare robots. Thus, even though common sense may suggest that healthcare robots would be appropriate for people with positive emotions and inappropriate for people with negative emotions, the current study appears to show that it matters much more that people feel they have the skills and abilities to cope with their emotions for them to be open to a robot or not. Emotions as such do not seem to influence people's perceptions of (future) healthcare robots, but rather it seems as though the extent to which they *believe* they can cope with their emotions does influence their perceptions of such robots. And maybe one day, robots even may help us in acquiring that belief as well.

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Appendix

Newspaper article (fictitious) about healthcare robot Alice

Are Caredroids the future?

By 2030, 1 in every 8 people worldwide is expected to be 65 years or older. The Central Bureau of Statistics has calculated that 1 in 4 people will be 65 or up by 2040. The demands for care will thus rise, which will put increasing pressure on the health-care system. To meet these demands, 1 in every 5 people should be working the healthcare sector by 2025. An impossible task, especially if we consider the simultaneously shrinking labor force.

AMSTERDAM – Technological innovation may provide a solution for this problem. For instance, in the form a human-like healthcare robot; a so-called Caredroid. Alice (see pictures) is such a robot; she looks like a little girl, has blue hair, and is 70 centimeters tall. Alice's face looks and feels like real skin. In addition, her face can show all kinds of emotions while she's having a conversation with you.

For instance, she can chat or play a game with a lonely elderly person, or try to motivate a disabled person to go out and do something. Whereas most healthcare professionals don't have time to listen to an elderly person tell the same story twice, Alice doesn't mind to hear the same story over and over (and over) again. Furthermore, Alice can help finding the right healthcare professional for a specific healthcare issue and she can register health complaints and pass them along to a GP if necessary. Finally, Alice could help you make your bed or remind you to take your medication. In about 10 to 20 years, healthcare robots like Alice are expected to be deployed in healthcare institutions or in people's homes to enable people to stay in their own homes for longer periods of time.

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