Summary

The increasing pressure on healthcare, due to decreasing resources, shrinking workforces, and an aging population, creates the necessity for solutions that enable us to provide everyone with the care that is needed while at the same time relieving (some of) the pressure on healthcare. One of the potential solutions for this problem is the deployment of technology such as robots. However, people that oppose the use of robots and other technology in healthcare note that caring is not just about performing practical tasks, but also about the patient’s experience. In fact, patients also have emotions and cognitions that have to be taken care of. Thus, it is essential to take this experience into account when considering potential solutions for healthcare. After all, it is not unthinkable that a patient in a negative emotional state will not be open to a healthcare robot, and if that is the case it may not be the right choice to turn to robots to relieve the pressure on healthcare. Therefore, this dissertation is focused on the influence that emotions may have on people’s perceptions of robots in a healthcare context.

The studies reported in this dissertation are centered around the influence of emotions on the perceptions that people have of humanoid social robots in the healthcare domain. Humanoid social robots are characterized by humanlike looks and behavior. For instance, they have legs, arms, and a face just like us, and they are increasingly able to behave and communicate like us. Thus, the focus of this dissertation is not on robots that can perform all kinds of practical tasks (such as vacuum robots) or that monitor the user (such as fall detection robots), but we focus explicitly on robots that are meant to communicate with human users (i.e., social robots). We used two different social robots in our research: Alice and Zora (see Chapter 1 for pictures of both robots).

In the emotion literature, we found two theories that provide a possible explanation for how and why people’s emotions may influence their perceptions of social robots such as Alice and Zora. The first of the two theories, Barbara Fredrickson’s (1998; 2001) broaden-and-build theory, is based on the valence of an emotional state. According to this theory, negative emotions make people focus their attention to the issue at hand (i.e., it narrows their focus), whereas positive emotions lead to a broader and more open focus. From this, it seems logical to expect that people that experience positive emotions see more possibilities with the robot and will be more open for robots compared to people that
experience negative emotions. Thus, based on this theory, the valence of an emotional state plays a crucial role in influencing perceptions of robots. The other theory, the appraisal-tendency theory by Lerner and Keltner (2000; 2001), assumes that not only the valence of an emotion matters, but also several other appraisal dimensions related to the emotional situation may be important in influencing perceptions of a robot. Different emotional states are characterized by distinct patterns of these appraisals. For instance, anger and fear are both appraised as having negative valence, yet anger is characterized in addition by appraisals of other-responsibility, high personal control, and certainty, whereas fear is characterized by appraisals of low personal control and uncertainty about the emotional situation. Based on this, the appraisal-tendency theory predicts that the appraisals associated with an emotional state may lead to a tendency to appraise future situations in a similar fashion. For instance, the appraisal-tendency theory predicts that fearful people have a higher tendency to appraise future situations as uncertain compared to angry people. Similarly, people that experience different emotions will have different appraisal tendencies when they are confronted with a robot, even if those people experience emotions of the same emotional valence. Thus, based on the broaden-and-build theory we may expect that the valence associated with one’s emotional state influences his/her perceptions of a robot, whereas the appraisal-tendency theory predicts that differences in appraisals between emotional states may lead to differences in the influence on perceptions of the robot.

To study the influence of users’ existing emotions on their perceptions of robot Alice and the fit of both these theoretical perspectives with our results, we performed a first experiment \( N = 184 \) in Chapter 2. To assess the fit of the two theories with regard to the influence of emotions on perceptions of the robot, we compared different emotional states in the experiment. We used both negative and positive emotional states to study the role of valence. Additionally, we used multiple emotional states that were characterized by different appraisal patterns, so that we could study the influence of appraisals (i.e., we used multiple negative and positive emotional states). Study participants were instructed to recall a situation related to healthcare or illness in which they experienced the emotion that was randomly assigned to them (for example, sadness due to pain and loneliness during a long period of illness). Next, they read a (fictitious) newspaper article about robot Alice that was going to be introduced as a healthcare robot, followed by a questionnaire to assess their perceptions about Alice. Results of this experiment seemed to suggest that the people in the
different emotional states did not directly differ from one another with regard to their perceptions of robot Alice. Yet, as expected, the emotional states did turn out to be related to different appraisals. Of those appraisals, the appraisal of coping potential (i.e., an evaluation of beliefs about one’s ability to cope with their emotions) did appear to influence some of the perceptions that people had about robot Alice. Participants who appraised their potential to cope with their emotions as high had generally more positive perceptions about the robot than participants who appraised their potential to cope with their emotions as rather low. Thus, the appraisal-tendency theory seemed to provide a better fit with the results than did broaden-and-build theory.

The aim of the next study (in Chapter 3) was to further study the role of appraisals and coping. Specifically, we wanted to study how emotion-related appraisals would influence the coping strategies that participants (N = 132) used and how those coping strategies in turn would affect the perceptions of the robot. In the literature on coping, a distinction is made between problem-focused and emotion-focused coping strategies. The first are aimed at changing or tackling the problematic situation that is causing the emotion, while the latter are aimed at changing the emotion itself. Earlier studies suggested that appraisals of control or power could be related to the choice of coping strategies. That is, when people experience control or power over an emotion-invoking situation, they are more likely to choose problem-focused coping strategies compared to people who do not experience control or power over an emotion-invoking situation (whom are more likely to choose emotion-focused coping strategies). To see whether this also played a role in influencing the perceptions of the robot, we did not only ask participants to recall a situation in which they experienced a particular emotion, but we also asked them to think of a situation that was either really hard to cope with (i.e., low coping potential), or relatively easy to cope with (i.e., high coping potential). After this recall procedure, participants talked to robot Alice via on-screen videos. In line with the findings from our previous study, the results seemed to suggest that participants that appraised their coping potential as high had more positive perceptions about the robot than participants that appraised their coping potential as low. Even though we did expect an influence of the appraisal of coping potential on the coping strategies that people would use, the experiment did not provide support for this hypothesis. However, results hinted that the use of the positive emotion-focused coping strategy was positively related to perceptions of the robot, whereas the use
of other coping strategies was not related to perceptions of the robot. So, we again seemed to have found that the emotions indirectly influenced perceptions of the robot via the extent to which people though they would be able to cope with their emotions (i.e., the appraisal of coping potential) and the use of the positive emotion-focused coping strategy.

In order to see whether we could replicate these findings when participants were to talk to a physically present robot (instead of talking to the robot on a screen), we performed two additional experiments in Chapter 4. This time, we used a different procedure to induce emotions and high or low coping potential: Instead of asking participants to recall an emotional situation participants were asked to imagine an emotional scenario. The participants in the first experiment in Chapter 4 ($N = 101$) were instructed to have a conversation with robot Zora after having read (and imagined) the emotional scenario. These participants were told that they would be participating in a study about emotional experiences, and thus did not know beforehand that they would talk to a robot during the experiment. Interestingly, this experiment led to different results than the two earlier experiments (in Chapters 2 and 3) in that we did not find the influence of the appraisal of coping potential in this experiment. We reasoned that this may have been due to the surprise effect that the sudden presence of the robot had on the participants. After all, it was the first time that the majority of the participants met a real-life humanoid robot, let alone that they had any experience in talking to such robots. In hindsight it make sense that such a new experience could cancel out any previous (emotional) influences. Therefore, we decided to replicate this experiment, yet this time we informed participants ($N = 110$) beforehand that the study would entail talking to a robot as well as letting the participants have a short ‘practice talk’ with the robot before they were instructed to recall any emotions (using the same emotional scenario method). Again, we could not replicate the results of the first two experiments, nor any of the hypothesized effects via the use of coping strategies. It seemed as though physically meeting and talking to the robot triggered other influences for the participants than the emotional influences that were found when reading about a robot or talking to the robot on a screen. This finding is very relevant in light of the fact that quite some research on robots is being done using pictures and on-screen versions of robots, while our studies show that meeting a robot ‘in the flesh’ appears to be a different experience than meeting a virtual or 2d version of a robot.
In *Chapter 5*, the General Discussion, we discuss the conclusions that can be drawn from our studies as well as how they relate to the existing research literature. The results of the first two experiments in particular seem to provide some theoretical support for the appraisal-tendency theory, as the appraisal of coping potential appears to play an important role in influencing the perceptions that participants had of the robot. However, this does not mean that we should bluntly dismiss the broaden-and-build theory. In fact, the finding that people who appraised their coping potential as high were more positive about the robot than people who appraised their coping potential as low could be an indicator that it might not so much be emotional valence but rather that it may be the appraisal of coping potential that can influence whether or not a person is willing to engage with a robot. Another important finding from our studies is the fact that the physical presence of the robot seems to have led to different results compared to the studies in which the robot was not physically present. It appeared as though actually meeting a physically present robot led to a different way of processing of the robot compared to when people only read about the robot or talked to it on-screen. Particularly, physically meeting a robot appeared to activate a process in which schema’s that we have about human-human interaction were applied to human-robot interaction. However, it is also very well possible that the fact that we did not find the same results in the latter two studies (reported in *Chapter 4*) as we did in the first two studies (in *Chapters 2 and 3*) could be related to the surprise about meeting the robot, or the fact that meeting a robot was such a new experience. Perhaps the influence of existing emotions may show up again when people are becoming more experienced and proficient with robots.

Besides discussing the conclusions and theoretical implications, we also discussed several methodological strengths and weakness of our studies in *Chapter 5*. For instance, our studies showed that inducing emotions was not an easy feat. We explicitly looked for rather intense emotional experiences that are similar to those actually found in healthcare contexts. Yet, despite our best efforts to find fitting and relevant emotion induction procedures, it appeared to be quite difficult for most participants to really engage emotionally with the emotion induction procedures. For this reason, we used two different procedures to induce emotions (i.e., recalling an emotional experience and reading an emotional scenario) in our studies. Nevertheless, it still appeared difficult for participants to really imagine or recall the emotional experience, which is a known problem in emotion induction.

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research. The use of both methods to induce emotions is at the same time also a strong point, as it allowed us to take advantage of the benefits of both methods without losing sight of the relevance of the emotion to the user (the latter sometimes being the case when using videos or music to induces emotions). Another strength of this dissertation is the fact that it is highly theory-driven, based on literature from human-robot interaction as well as literature on emotion and coping. Thus, our results also provide valuable guidelines for new research in these fields.

One of the important challenges for future research is to try to replicate these findings in studies in both the lab as well as the field. Furthermore, it is interesting to study these emotional influences on the longer term and with different kinds of physically present robots. As discussed earlier, the influence of emotions on perceptions of the robot (as we seemed to have found in Chapters 2 and 3) may again resurface when people get more accustomed to robots. So it would be interesting to study the long-term influence of existing emotions among users on their perceptions of robots, but also on their willingness to interact with the robot, and the way they bond with robots. Furthermore, it is important to consider that the results in this dissertation all came from controlled lab environments, mostly using a student population. This guided us to interesting insights about the role of emotions, appraisals, and coping, yet at the same time this makes it difficult to translate our results to everyday practice. Of course, (potential) users will not meet robots in such controlled environments when robots are deployed in actual healthcare settings. Thus, to better understand how emotions, appraisals, and coping may actually have an influence in practice, research in the field is needed in which the way patients and robot interact are studied in great detail, as well as studying these patients’ emotional and coping experiences. In addition, we limited ourselves to one interaction task with the robot in the studies reported in this dissertation (i.e., an interview to gain information about the participant). Perhaps the influence of emotions on perceptions of the robot would be different if other kinds of interaction tasks were performed (such as jointly solving a puzzle, or the robot trying to convince the user to behave more healthily), although more research is needed to see if this is indeed the case.

Finally, we also discuss some practical implications in Chapter 5. For instance, the studies in this dissertation seem to suggest that users probably need some time to get used to talking to robots. From our personal observations during the last experiment, we saw that
participants already appeared to be more at ease with talking to the robot if they had a short talk with the robot before the emotion induction procedure. Related to this was the fact that some participants in the experiments in Chapter 4 indicated that the conversation with the robot had a somewhat artificial, unnatural feel to them, which may have been caused by the strict protocol that was followed to ensure that all participants experienced the conversation with the robot similarly. Less artificial conversations could very well be possible in practice, for instance by letting the conversation flow more freely and by letting the robot use non-verbal behaviors such as gaze or gestures. Furthermore, it is important to think about the ethical aspects related to the deployment of robots in actual healthcare situations. One may, for instance, wonder about the moral acceptability of using robots to fob off patients in desperate need of care. Or about who will be responsible if a patient has really bonded with a robot and the robot breaks down. Or about what happens to the data that the robot collects, who is able to see these data and how we can ensure that these data are protected. These are the kinds of questions that become increasingly important when robots are deployed in actual healthcare settings.

In all, it seems to be important to account for the user’s emotions and appraisal of coping potential when robots are introduced. It appears that it may not be beneficial to confront people with a healthcare robot when they experience emotions that they appraise as very hard to cope with (regardless of the valence of their emotions and their actual ability to cope with their emotions). When people appraise their emotional situation as hard to cope with (i.e., low coping potential), they appear to be less positive about the robot and subsequently they may be dissatisfied with the way they are cared for. The results of these studies thus show that it seems important to take into account the context in which people will be facing such social robots. Healthcare professionals are thus advised to critically reflect not only on who may (potentially) benefit from social robots, but also on the best moment to introduce such robots.