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

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Chapter 4

How emotions and emotional coping shape perceptions in interaction with a humanoid social robot

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Abstract

The increasing pressure on healthcare systems calls for innovative solutions, among which social robots. However, healthcare situations often are highly emotional while little is known about how people's prior emotional state may affect the perception and acceptance of such robots. Following appraisal theories of emotion, the appraisal of coping potential related to one's emotions was found to be important in acting as mediator between emotional state and perceptions of a robot (Spekman et al., 2018a; 2018b), though this has not yet been tested in relation to *actual* emotional coping nor in an *actual* encounter with a robot. Hence, the current study focused on how actual emotional coping influences subsequent robot perceptions in two experiments. In Study 1 (N = 101) and Study 2 (N = 110) participants encountered a real humanoid robot after a manipulation to induce various emotions and coping potential. Manipulations in both studies were effective, yet the results in Study 1 appeared to be confounded by a novelty effect of participants' first encounter with a real robot that talked to them. Therefore, participants interacted briefly with the robot before the actual experiment in Study 2. Results suggested that there was an interaction effect of prior emotions and (manipulated) coping potential on robot perceptions, but no evidence was found for the effects that were expected based on previous studies. These findings are, finally, discussed in light of the healthcare context in which these social robots will be deployed.

How emotions and emotional coping shape perceptions in interaction with a humanoid social robot

Increasing pressure on both acute and long-term healthcare due to growing elderly populations worldwide (World Health Organization, 2015) combined with severe budget cuts force societies to look for solutions to relieve some of this pressure on healthcare systems. These solutions may partly be found in the field of new communication technologies. A highly promising new development in this regard is social robotics, which has thus far shown to enhance (social) interaction to relieve loneliness, to increase therapy adherence (i.e., remind people to take medication), and to motivate people to stay fit (Broadbent, Stafford, & MacDonald, 2009; De Graaf, Ben Allouch, & Klamer, 2015; Hoorn, Konijn, Germans, Burger, & Munneke, 2015; Van Kemenade, Konijn & Hoorn, 2015). Thus, social robots may play an important role as interaction partners in future healthcare. Therefore, it is important and timely to study how individuals perceive and accept such robots as interaction partners.

Most literature on perceptions of social robots focusses on how people feel about the robot *after* they have interacted with the social robot. Thus far, however, little attention has been paid to the effect that prior (or so-called 'incidental') emotions may have on people's perceptions of such robots, while a study among residents of a retirement village showed that prior negative perceptions of robots may prevent people from interacting with robots in the first place (Stafford, MacDonald, Jayawardena, Wegner, & Broadbent, 2014). The idea that prior emotional states and attitudes may affect people's perceptions of robots is also supported by findings from a study by Broadbent and colleagues (2010) in which they compared blood pressure readings performed by a robot to those performed by medical students. Their findings showed that participants were less comfortable with the robot and thought its blood pressure readings were less accurate than the medical students' blood pressure readings, even though there were no actual statistical differences in the accuracy of both blood pressure readings. Additionally, they found that positive prior emotions and attitudes about robots in general had positive effects on perceptions of the medical robot,

which may in turn affect acceptance and actual use of such robots. This may be particularly relevant in a healthcare context, as many healthcare situations go hand in hand with intense, often negatively toned emotions (e.g., feeling sad or angry after losing one's physical ability or being anxious for a pending diagnosis). Thus, it is likely that such intense emotional states affect subsequent perceptions of (interactions with) a healthcare robot.

So how do these emotions affect perceptions? According to appraisal theory, each emotional situation is characterized by a set of distinct appraisals (Frijda, 2007). Following the appraisal-tendency framework (Lerner & Keltner, 2000; 2001), (incidental) emotions can influence perceptions of future, unrelated situations via the transfer of appraisals of the current (emotional) situation to those of future situations. For instance, anger is characterized by appraisals of high novelty, very high outcome certainty, goal obstruction, high urgency, other agency, and high control (Ellsworth & Scherer, 2003). These anger appraisals can then transfer to a future (unrelated) situation, leading to behaviors that are in line with anger appraisals (e.g., higher risk-taking, as shown in Lerner & Keltner, 2000). In other words, a given situation is appraised in a certain way and these appraisals may transfer to an unrelated situation in the future.

Previous studies that applied this appraisal-tendency framework to study the role of emotions in interactions with healthcare robots found that especially the appraisal of coping potential played an important role, as it was found to mediate the effects of emotions on perceptions of social healthcare robots (Spekman, Konijn, & Hoorn, 2018a; 2018b). Particularly, if people *believed* that they could cope with an emotional situation, they were more positive about the robot. Yet, those previous studies applied a procedure in which the participants were asked how they would respond to meeting a robot after reading either a newspaper article about the robot or watching on-screen videos of the robot. It is, however, very well conceivable that interacting with an actual, real-life humanoid robot may evoke more intense or even different responses. Therefore, in the current study we examined the same idea of applying the appraisal-tendency framework to human-robot-interaction, but this time the participants were interacting with real-life robots rather than reading a newspaper article about a robot or watching video footage of a robot. Thus, this study was guided by the following research question (RQ1): How is the appraisal of coping potential related to perceptions of a humanoid healthcare robot?

Because the appraisal of coping potential is closely related to actual coping (Lazarus, 1999), we considered it important to examine what role *actual* coping plays in the effect of emotion on perceptions of a healthcare robot. Lazarus (1999; 2001) distinguishes two major types of coping strategies: problem-focused coping strategies, which are basically aimed at changing the situation, and emotion-focused coping strategies, which are aimed at changing the emotional experience itself. Imagine, for example, a situation in which you are angry because the plumber did not fix the pipes properly. Problem-focused coping strategies in this case could be fixing the pipes yourself or calling a different plumber to do it for you, while an emotion-focused coping strategy might be to call the plumber and yell at him so as to vent your anger. Generally speaking, people who feel in control over a situation and think that they are able to change the situation will use problem-focused coping strategies, whereas people who feel they lack control over the situation or are unable to change the situation are inclined to use emotion-focused coping strategies (Chiavarino et al., 2012; Glanz & Schwartz, 2008; Lazarus, 1999; Lazarus & Folkman, 1984). Since the appraisals of control and coping potential are closely related, it seems logical that a high potential to cope is related to more control, and consequently also to the choice of coping strategies. Following the above, we expect that a high potential to cope with an emotional situation will be related to the use of problem-focused coping strategies, whereas a low coping potential will be related to the use of emotion-focused coping strategies (H2).

Furthermore, we expect the use of coping strategies to be related to perceptions of a social robot in a similar fashion as the appraisal of coping potential in previous studies (Spekman et al., 2018a; 2018b). In those studies, the appraisal of coping potential was found to mediate the effect of emotion on perceptions of the robot. Following the appraisal-tendency framework and the mechanism described above, we expect that use of problem-focused coping strategies are used when coping potential is high (cf. H2), and consequently leads to more positive perceptions about the social robot, while the use of emotion-focused coping strategies has the opposite effect. Thus, the use of problem-focused coping strategies is expected to be positively related to perceptions about a healthcare robot (H3a). By contrast, a negative relationship is expected for the use of emotion-focused coping strategies (H3b).

Study 1

In order to test the hypotheses and research question, emotional state and coping potential were manipulated. We chose to induce two different emotional states, anger and sadness, as they both often occur in healthcare contexts (based on informal interviews with healthcare professionals and literature such as Olsson et al., 2003). Furthermore, the literature showed that these emotions differed from each other on the appraisal of coping potential (among others): Angry people generally blame others and experience a high potential to cope with the situation, while sad people in general appraise their situation as being low in (problem-focused) coping potential (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003; Lowe et al., 2003). These emotional states were induced using a scenario method which is described in more detail in the Methods section below. Coping potential was manipulated by an appendix to this scenario which created either a changeable/controllable situation (i.e., creating a high potential to cope with the situation) or an uncontrollable situation (i.e., low coping potential). A graphical overview of the study is found in Figure 1 below.

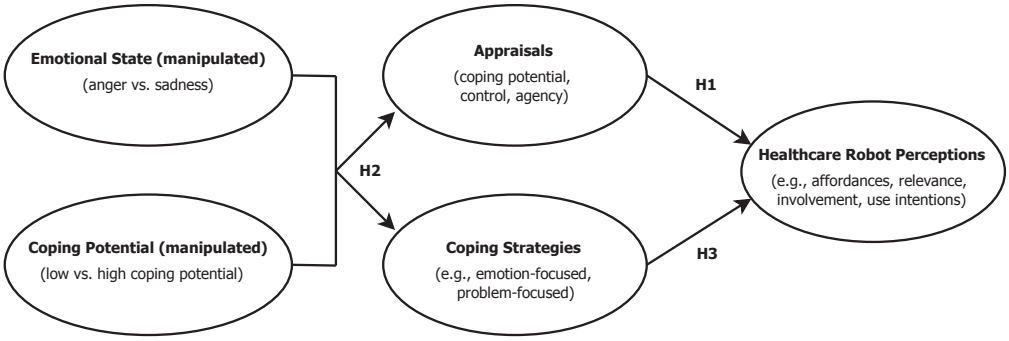

Figure 1. Graphical representation of the theoretical framework used in the current studies.

Methods

Participants and design

A total of 101 university students (74.3% female, M_{age} = 21.38, SD_{age} = 6.77) were randomly assigned to one of the conditions in a 2 (induced emotion: sadness vs. anger) x 2 (manipulated coping potential: low vs. high) between-subjects lab experiment. Participants

received either course credit or a gift certificate in return for their participation. No differences were found between conditions in terms of age, education, sex, and familiarity with robots in general.

Manipulation

Emotional state and coping potential were manipulated using a scenario method. The scenarios for emotional state were similar to those used by Green and Sedikides (1999): Participants in the sad condition imagined being present at their best friend's funeral, whereas participants in the angry condition imagined a fellow student in their group freeriding and subsequently blaming the participant for freeriding, resulting in a lower grade for the participant (see Appendix 1 for complete scenarios).

To manipulate coping potential, an extra paragraph was added to the emotional scenario. Based on the idea that coping potential is high when the situation is changeable/controllable (Lazarus, 1999), we added a paragraph that (fictitiously) either enabled the participant to change something about the imagined scenario or a paragraph showing the participant's inability to change or control the situation (cf. Harmon-Jones et al., 2003). For the sad condition, low coping potential was manipulated by adding that the friend's death was very sudden and tragic, whereas high coping potential was manipulated by adding that the friend had been sick and suffering for a long time and that dying was probably a relief for him/her. In the angry condition, we added either that the teacher had finalized the grades already and nothing else could be done about the situation (i.e., low coping potential) or that the teacher did not finalize the grades yet and the participant found a phone number to contact the teacher to talk about it (i.e., high coping potential).

These four scenarios were pre-tested among 62 university students (different from the participants in the actual study) to check whether the scenarios induced the intended emotional states and levels of coping potential. Results showed that participants indeed experienced the intended emotional states and different levels of coping potential (see Appendix 2 for an overview of pre-test results).

Procedure

University students from various disciplines were recruited on campus to participate in a study about imagining and dealing with emotional situations. They were not informed about the role of the robot in the study. Upon entering the lab, participants were seated behind a computer and asked to read and follow on-screen instructions closely (see Figure 2, left image). Participants were then instructed to imagine as vividly as possible their assigned emotional scenario as if the situation really happened to them. After reading the emotional scenario, participants were asked to ruminate and describe their feelings about the situation (cf. Green & Sedikides, 1999), and to report the intensity of their anger and sadness. Next, participants were presented with one of the coping potential manipulation paragraphs (i.e., low vs. high coping potential), followed by measures to assess their appraisals and the coping strategies that participants would use to deal with the emotional situation they had just imagined.

At this point, participants were instructed to go to another desk, separated from the first desk by divider screens (see Figure 2, right image). On this desk, a humanoid Nao-robot Zora was awaiting the participant and opened the conversation. Zora is a Nao robot created by Aldebaran combined with the user-friendly software developed by QBMT. Up until this moment, participants were unaware that they would interact with a physically present robot. The robot started talking to the participant via a Wizard-of-Oz protocol. In a Wizard-of-Oz protocol, the robot is controlled from a distance by a researcher instead of functioning autonomously (Dix, Finlay, Abowd, & Beale, 2004). The conversation with Nao/Zora about the participant's health and wellbeing was pre-scripted and was based on the Manchester Short Assessment of Quality of Life questionnaire (Priebe, Huxley, Knight, & Evans, 1999). Thus, the robot acted as if it were a doctor's assistant preparing a diagnosis. Participants' answers to the robot's questions were only used by the experimenter to inform the robot's next question and to provide answers (i.e., they were not part of data collection).

After talking to the robot, participants were instructed to return to the first desk to evaluate the interaction and answer questions about their perceptions of robot Nao/Zora. Participants were then given the opportunity to provide feedback on Nao/Zora and

healthcare robots in general, followed by measurements of demographics and familiarity with robots. Finally, participants were debriefed and thanked for their participation.

Figure 2. Experimental setup: a participant (blurred) filling out the questionnaire at desk 1 (*left image*), and desk 2 on the other side of the divider screens for the participant's conversation with robot Nao/Zora (*right image*).

Measures

Manipulation check of induced emotions. Intensity of anger and sadness experienced after imagining the emotional scenario was assessed using 1 item for each emotional state. Participants were asked to indicate the extent to which they experienced anger or sadness using a slider ranging from 0 ("not at all") to 100 ("very strongly").

Appraisals of coping potential and related appraisals. We judged most of the available scales in the literature inappropriate for our study's purposes, either because they were confounded with the assessment of others appraisals (such as power, agency, or control, cf. Ellsworth & Scherer, 2003), or because they were focused specifically on emotion-focused or problem-focused coping potential, whereas we aimed for a more general measure of coping potential. Therefore, we created a 5-item scale to assess the general appraisal of coping potential (e.g., "I think it will be tough to deal with this situation"). Answers were given on 5-point rating scales (5 = fully agree). After recoding two negatively worded items, the 5 items together formed a reliable scale (Cronbach's α = .88).

Closely related to the appraisal of coping potential are *appraisals of agency* and *control* (Smith & Ellsworth, 1985). The appraisal of agency covered other-agency (single item; "something or someone else than me is responsible for this situation"), self-agency

(single item; "I myself am responsible for this situation"), and situational agency (2 items[1]; e.g., "the situation was caused by circumstances beyond human control"; $R_{\text{Spearman-Brown}}$ = .86). The control appraisal was measured using 2 items (e.g., "I am convinced that I can change this situation"), which together formed a reliable scale ($R_{\text{Spearman-Brown}}$ = .88). See Appendix 3, Table 1 for an overview of all appraisal items and PCA results.

Perceptions about robot Nao/Zora. Perceptions about the robot were assessed by means of a framework for Interactively Perceiving and Experiencing Fictional Characters (I-PEFiC; e.g., Van Vugt, Konijn, Hoorn, & Veldhuis, 2009). A total of 39 statements were used to assess the 9 dimensions of the I-PEFiC framework. The degree of fit with the participant's perception of robot Nao/Zora was given per statement on 5-point rating scales (1 = "does not fit at all"; 5 = "fits very well"). Statements were both positively and negatively worded and the latter were recoded before analyses. We briefly describe the scales below, a full overview of the scales and items used can be found in Appendix 3, Table 2.

Perceived ethics of Nao/Zora was assessed by means of 4 statements. The items formed a reliable scale (Cronbach's α = .71). *Perceived affordances of Nao/Zora* was assessed using 7 items, four of which formed an optimal scale (Cronbach's α = .81). *Perceived aesthetics of Nao/Zora* was measured with 4 items (Cronbach's α = .68). *Perceived realism* was measured using 4 items (Cronbach's α = .66). *Perceived relevance of the robot* was measured using 4 items (Cronbach's α = .65). *Perceived valence of Nao/Zora* was assessed by means of 4 statements (Cronbach's α = .86). *Perceived involvement with Nao/Zora* was assessed using 4 items (Cronbach's α = .84). *Perceived distance between the user and Nao/Zora* was measured using 4 statements (Cronbach's α = .65). Finally, *perceived use intentions of robot Nao/Zora* was assessed by means of 4 items (Cronbach's α = .74).

Coping strategies. We used the 28 items of the Brief COPE (Carver, 1997) to assess which coping strategies participants would use to cope with the situation they had imagined. Participants indicated for each strategy the extent to which they would perform that strategy on 5-point rating scales (1 = "I would certainly NOT do this", to 5 = "I would

[1] The reliability of two-items scales was assessed using Spearman-Brown's coefficient, as it is more appropriate than Cronbach's alpha or Pearson's coefficient for two-item scales (Eisinga, Te Grotenhuis, & Pelzer, 2012).

definitely do this"). Based on results from Principal Components Analyses (PCA) and reliability analyses, we found that an 8-factor solution was most optimal (see Appendix 3, Table 4 for an overview of items and subscales).

Problem-focused coping was assessed using 3 items (Cronbach's α = .81); *Support coping* consisted of 4 items (Cronbach's α = .80); *Emotion-focused coping* was also assessed by means of 4 items (Cronbach's α = .82); *Humor coping* consisted of 2 items ($R_{\text{Spearman-Brown}}$ = .82); *Denial coping* was also measured by means of 2 items ($R_{\text{Spearman-Brown}}$ = .82); *Self-distraction coping* was measured with 2 items ($R_{\text{Spearman-Brown}}$ = .71); *Substance (ab)use coping* was assessed using 2 items ($R_{\text{Spearman-Brown}}$ = .96); *Spiritual coping*, finally, also consisted of 2 items ($R_{\text{Spearman-Brown}}$ = .85).

Results and discussion

Manipulation checks

Manipulation checks for intensity of emotion were successful: Sad participants experienced significantly more intense sadness (M = 64.45, SD = 28.67) compared to angry participants (M = 29.86, SD = 23.00) whereas the latter experienced significantly more anger (M = 67.24, SD = 18.00) than the first (M = 17.31, SD = 19.93; both $p < .001$, $\eta_p^2 > .30$). No differences were found for the coping conditions or the interaction of emotion and coping conditions (all *ns*) in terms of emotion intensity.

To check whether the manipulation of coping potential was successful, we performed a MANOVA with manipulated coping potential as independent variable and the appraisals (i.e., coping potential, agency, and control) as dependent variables. A significant multivariate effect was found for manipulated coping potential, Wilk's λ = .71, $F(5,86)$ = 6.87, $p < .001$, η_p^2 = .29. Univariate results confirmed significant effects for the appraisals of coping potential, $F(1,90)$ = 4.15, p = .045, η_p^2 = .04, situational agency, $F(1,90)$ = 7.29, p = .008, η_p^2 = .08, and other-agency, $F(1,90)$ = 11.75, p = .001, η_p^2 = .12. No significant effects were found for control and self-agency (both *ns*). As expected, the high coping potential scenario was appraised as significantly easier to cope with (M = 2.97, SD = 1.01) than the low coping potential scenario (M = 2.56, SD = .92). Thus, both the manipulation of coping potential and emotional state were successful.

Testing hypotheses

We first looked at the role that the appraisal of coping potential played in the effect of emotions on perceptions of a social robot (RQ1). We tested this using a two-step approach: 1) test for differences between conditions on the appraisal of coping potential, and 2) test whether the appraisal of coping potential influenced the perceptions of the robot.

To test step 1, a MANOVA was performed with manipulated emotional state and coping potential as independent variables and the appraisals as dependent variables. Results showed significant multivariate effects for both main effects as well as the interaction of emotional state and coping potential, all Wilk's λs $\leq .76$, Fs $(5,84) \geq 5.29$, ps $< .001$, η_p^2s $\geq .24$. Univariate results for the appraisal of coping potential showed that emotional state as well as manipulated coping potential had significant effects: Participants in the anger and high coping potential conditions appraised their potential to cope with the situation as larger than participants in the sad and low coping potential conditions (both ps $< .01$, η_p^2s $> .10$). Similar effects were found for the appraisals of control and situational agency (see Appendix 4 for a full overview of results).

In step 2, we tested whether the appraisals affected the perception of the robot using regression analysis for each of the perception measures. We found that the appraisal of other-agency had a significant positive effect on perceived relevance of the robot, $b(SE_b) = .17(.05)$, $\beta = .34$, $p = .002$, 95% CI [.06, .27], as well as marginally significant positive effects on perceived ethics, $b(SE_b) = .10(.06)$, $\beta = .20$, $p = .087$, 95% CI [-.01, .21], and perceived involvement, $b(SE_b) = .11(.07)$, $\beta = .19$, $p = .094$, 95% CI [-.019, .238]. Results also showed a marginally significant effect of self-agency the perceived realism of the robot, $b(SE_b) = .15(.09)$, $\beta = .25$, $p = .098$, 95% CI [-.03, .32]. Most importantly for answering our research question, we found that the appraisal of coping potential did not have an effect on any of the perceptions measures (all *ns*). Thus, we did find that the manipulated emotions had an effect on the appraisal of coping potential, but it did not in turn affect perceptions of the robot.

Next, we tested H2, which predicted that high coping potential would be related to the use of more problem-focused coping strategies and low coping potential would be related to the use of more emotion-focused coping strategies. To test this, we used a mixed-design MANOVA with manipulated emotional state and coping potential as between-

subject factors, and the 8 coping strategies as within-subjects factor. Within-subjects effects were found for coping strategy[2], $F(5.25,509.67) = 100.09$, $p < .001$, $\eta_p^2 = .51$, and the interaction of coping strategy and manipulated emotional state[2], $F(5.25,509.67) = 19.07$, $p < .001$, $\eta_p^2 = .16$. For the coping strategies used, results from pairwise comparisons showed that especially the support and problem-focused coping strategies were used more often than the other strategies (*p*s <.005), whereas the coping strategies of denial, humor, substance (ab)use, and spiritual coping were used less often than the other strategies (*p*s < .001).

In relation to the interaction of coping strategy and emotional state, we found in the pairwise comparisons that the angry and sad participants differed significantly in their use of all coping strategies (all *p*s <.02) except for the support coping strategy. This was qualified by a between-subject effect of emotional state: Compared to sad participants, angry participants used significantly more problem-focused and humorous coping strategies and fewer emotion-focused, denial, distraction, substance (ab)use, and spiritual coping strategies (all *p*s < .02). Yet, the effect of manipulated coping potential on the use of problem-focused and emotion-focused coping strategies as predicted in H2 was not found.

Finally, we tested whether the use of certain coping strategies related to the robot perception measures, as expected in H3, using a series of regression analyses (one for each of the perception measures). Results of these analyses showed that the use of the problem-focused coping strategy was positively related to intention to use the robot, $b(SE_b) = .23(.11)$, $\beta = .25$, $p = .038$, 95% CI [.01, .44], marginally significant and positively related to ethics ($b(SE_b) = .14(.08)$, $\beta = .20$, $p = .094$, 95% CI [-.02, .30]), and marginally significant and negatively related to distance ($b(SE_b) = -.16(.09)$, $\beta = -.22$, $p = .069$, 95% CI [-.34, .01]). Apart from distraction coping being significantly and positively related to perceived ethics of the robot ($b(SE_b) = .13(.07)$, $\beta = .22$, $p = .045$, 95% CI [.003, .26]), none of the other coping strategies were significantly related to any of the perception measures. Thus, limited evidence was found for H3a, which predicted a positive relationship between the use of problem-focused coping and perceptions of the robot, as this coping strategy was found to be positively related to use intentions and ethics and negatively related to distance. For H3b, which predicted negative relationships between the use of emotion-focused

[2] Degrees of freedom were corrected using the Greenhouse-Geisser correction.

coping and robot perceptions, we found no support, as emotion-focused coping was not related to any of the perception measures.

Because these finding are in clear contrast to earlier findings (Spekman et al., 2018a; 2018b), we reflected on our procedure and reasoned that participants must have been surprised by interacting with a physically present robot. That is, participants were unaware that they would be meeting a robot during the study. Most participants reported that they had never talked to a robot before, and participants were clearly surprised when they were instructed to move to the second desk where Nao/Zora was located. Further inspection of the results made it clear that the results follow our expectations up until the point that the participants met the robot. The surprise evoked by the robot likely overruled any preceding effects from our procedure. Thus, this called for a second study in which we aimed to rule out this novelty effect.

Study 2

Previous studies showed that the appraised coping potential mediated the relationship of (experimentally induced) emotions on participants' perceptions of a robot (Spekman et al., 2018a; 2018b). However, participants in those studies were not confronted with a real, physically present robot. Rather, they saw robots in video clips or read about them in news items. In contrast, in Study 1, reported above, the participants unexpectedly interacted with a real-life robot and then assessed their perceptions of the robot. As discussed, most participants indeed reported having been surprised about meeting the robot. This is an important lesson for subsequent studies.

In Study 2, we aimed to avoid this novelty effect that interrupted the process under study. Therefore, we deemed it important that participants would get acquainted with the robot prior to the interaction relevant for the study goals. In brief, we repeated Study 1 as closely as possible and only adjusted the procedure such that participants would already meet the robot in advance.

Methods

Participants and design

A total of 110 university students (64.5% female[3], M_{age} = 21.77, SD_{age} = 4.84) were, like in study 1, randomly assigned to one of the conditions in a 2 (induced emotion: sadness vs. anger) x 2 (manipulated coping potential: low vs. high) between-subjects lab experiment. They received either course credit or a gift certificate in return for their participation. No differences were found between conditions in terms of age, education, and prior experience with robots. We found that men and women were unevenly distributed across coping potential conditions, in that men were overrepresented in the low coping potential condition and underrepresented in the high coping potential condition. However, gender was found not to have effects on any of the dependent measures, so it was not further considered.

Figure 3. Experimental setup: left side of the lab with Nao/Zora placed on a low table in front of the participant when seated on the couch (*left image*), and right side of the lab where the participant read the emotional scenario and filled out the questionnaire (*right image*).

Procedure

The procedure in Study 2 was basically identical to Study 1, except for the invitation to participate in a study to talk to a robot and that participants had a short introductory conversation with the robot before starting the actual study. In this preparatory conversation, the robot introduced itself and asked the participant about their familiarity

[3] Thus, 34.5% male; one respondent chose not to answer the question about gender.

with robots, prior knowledge and attitudes about robots. After this brief initial meeting, which took approximately 3 minutes, the procedure was the same as in Study 1. This study took place in a different lab, however, so the lab space looked a little different. Both conversations with Nao/Zora took place on a couch (see Figure 3, left image), while the emotion induction in between the two conversations with the robot took place at a desk a few feet away in the same room (see Figure 3, right image). This is also where the participant completed the questionnaire after the conversations.

Measures

The measures in Study 2 were the same as in Study 1, except for some of the perception measures. Therefore, we will only discuss those scales that are dissimilar to the scales in Study 1. Because the reliability of some of the perception measures was a bit low in Study 1, we added extra items to several scales to obtain optimal scales. After item and scale analysis, all scales were reduced to 4 items. (for a full overview of scales and items there were used or not used in both studies, see Appendix 3, Tables 2 and 3).

Perceived ethics of Nao/Zora was assessed by means of 4 (out of 10) statements that formed a reliable scale (Cronbach's $\alpha = .77$). *Perceived affordances of Nao/Zora* was assessed using 4 items (out of 7) that formed an optimal scale (Cronbach's $\alpha = .77$). *Perceived aesthetics of Nao/Zora* was measured with 4 items (out of 8) that constituted a sufficiently reliable scale (Cronbach's $\alpha = .67$). *Perceived realism* was measured using 4 items (out of 8) that formed a reliable scale together (Cronbach's $\alpha = .81$). *Perceived distance between the user and Nao/Zora* was measured using 4 (out of 8) statements that together formed a reliable scale (Cronbach's $\alpha = .80$). Finally, *perceived use intentions of robot Nao/Zora* was assessed by means of 4 (out of 8) items that formed a reliable scale together (Cronbach's $\alpha = .83$).

Results

Manipulation checks

To test whether the emotional scenario's induced the intended emotion, results of a MANOVA showed that the intensity of emotions experienced differed significantly

between the emotion conditions (Wilk's $\lambda = .27$, $F(2,105) = 142.94$, $p < .001$, $\eta_p^2 = .73$). No differences were found in emotion intensity between the coping conditions or the interaction of emotion and coping (both *ns*). As expected, angry participants experienced anger significantly more intense ($M = 66.58$, $SD = 23.16$) than sad participants ($M = 15.44$, $SD = 22.75$), whereas sad participants experienced sadness more intensely ($M = 60.56$, $SD = 24.68$) than the angry participants ($M = 27.93$, $SD = 22.28$, both $p < .001$, $\eta_p^2 > .31$). Thus, the manipulation of emotion was successful.

Another MANOVA was performed to test whether coping potential was successfully manipulated. Results showed a significant multivariate effect of manipulated coping potential on appraised coping potential and related appraisals, Wilk's $\lambda = .78$, $F(5,104) = 5.74$, $p < .001$, $\eta_p^2 = .22$. Inspection of univariate effects showed that this multivariate effect was caused by differences between the two coping potential conditions on the appraisals of coping potential, $F(1,108) = 11.20$, $p < .01$, $\eta_p^2 = .09$, and the appraisal of situational agency, $F(1,108) = 4.17$, $p = .04$, $\eta_p^2 = .04$. No differences were found for the appraisals of control, self-responsibility, and other-responsibility (all *ns*). As intended, participants in the high coping potential scenario appraised the scenario as significantly easier to cope with ($M = 3.23$, $SD = .90$) than participants in the low coping potential scenario ($M = 2.66$, $SD = .87$). Thus, the manipulation of coping potential was also successful.

Testing hypotheses

To answer RQ1 about the relationship between the appraisal of coping potential and the perceptions of a social robot, we used the same two-step approach as we did in Study 1: 1) Check for differences between conditions in terms of appraised coping potential (using MANOVA), and 2) check whether appraised coping potential influenced perception measures (using a series of regression analyses).

In testing step 1, we found multivariate effects for both main effects as well as the interaction effect of emotional state and coping potential (Wilk's < .90, F's >3, p's <.02, $\eta_p^2 > .13$). Univariate results showed that both manipulated emotional state as well as manipulated coping potential significantly affected the appraisal of coping potential: Participants that were angry appraised their situation as easier to cope with than sad

participants, and participants in the high coping potential condition also appraised their situation as easier to cope with than participants in the low coping potential condition (both $p < .01$, $\eta_p^2 > .15$; see Appendix 4 for a full overview of results from this analysis).

From the regressions in step 2, we found that only the appraisal of self-agency had a significant negative effect on the perception of Nao/Zora's valence, $b(SE_b) = -.17$ (.09), $\beta = -.24$, $p = .049$, 95% CI [-.34, -.001]. None of the other appraisals had significant effects on any of the perception measures, and neither did the appraisal of self-agency affect any of the other perception measures except for perceived valence (all *ns*). Thus, we found a result similar to that in Study 1, in that the appraisal of coping potential was not related to any of the robot perception measures.

Next, we tested whether H2, which predicted that the conditions would differ in terms of the coping strategies used. We used another mixed-design MANOVA with manipulated emotional state and coping potential as between-subjects factors and the 8 coping strategies as within-subjects factor. Similar to Study 1, we again found within-subjects effects for coping strategy[4], $F(5.596,593.227) = 140.43$, $p < .001$, $\eta_p^2 = .57$, and the interaction of coping strategy and manipulation emotional state[4], $F(5.596,593.227) = 22.78$, $p < .001$, $\eta_p^2 = .18$. For the within-subjects effect of coping strategy, pairwise comparisons showed the same pattern[5] as in Study 1. Pairwise comparisons for the interaction of coping strategy emotional state showed that angry and sad participants differed in their use of all coping strategies (ps < .03) except for the support and spiritual coping strategies (both *ns*)[6].

Finally, and most important for the hypothesis, we also found a significant interaction of coping strategy and manipulated coping potential[4], $F(5.596,593.227) = 3.81$, $p = .001$, $\eta_p^2 = .04$. Pairwise comparisons showed that this within-subjects interaction of coping strategies and manipulated coping potential was qualified by significant differences between the high and low coping potential conditions for only two of the coping strategies. In contrast to our hypothesis (H2), which predicted a relationship between high coping

[4] Degrees of freedom were corrected using the Greenhouse-Geisser correction.
[5] The support and problem-focused coping strategies were used more often than the other strategies (ps < .01), and the denial, humor, substance (ab)use, and spiritual coping strategies were used less often compared to the other strategies (ps < .001).
[6] The interaction was qualified by a between-subjects effect for emotional state, suggesting that sad participants used more emotion-focused, more denial, more distraction, and more substance (ab)use coping strategies, and less humor and problem-focused coping strategies compared to their angry counterparts.

potential and problem-focused coping, and between low coping potential and emotion-focused coping, we found that participants in the high coping potential condition used less denial and more emotion-focused coping strategies compared to participants in the low coping potential conditions. Thus, results showed no difference in the use of problem-focused coping strategies and the opposite effect than hypothesized for the use of emotion-focused coping strategies. Furthermore, the overall between-subjects effect for manipulated coping potential was not significant. Thus, we again found no support for H2.

Finally, we tested whether the effect of coping strategies on participants' perceptions of robot Nao/Zora (cf. H3) using a series of regressions analyses for each of the perceptions measures with the coping strategies as independent variables. Results of these regressions showed that denial was positively related to perceptions of the robot's affordances ($b(SE_b)$ = .21(.08), β = .25, p = .016, 95% CI [.04, .37]), that substance (ab)use had a marginally significant negative effect on perceptions of the robot's ethics ($b(SE_b)$ = -.09(.05), β = -.17, p = .093, 95% CI [-.19, .02]), and that distraction was negatively related to the robot's perceived relevance ($b(SE_b)$ = -.19(.08), β = -.30, p = .024, 95% CI [-.35, -.03]). In addition, we also found that emotion-focused coping had a significant positive effect on perceived relevance of the robot ($b(SE_b)$ = .18(.07), β = .27, p = .016, 95% CI [.03, .32]), a marginally significant positive effect on perceptions of the robot's ethics ($b(SE_b)$ = .09(.05), β = .21, p = .067, 95% CI [-.01, .19]), and a marginally significant positive effect on the perceived intention to use the robot ($b(SE_b)$ = .18(.10), β = .21, p = .078, CI [-.02, .39]). No effects of problem-focused coping were found (all *ns*). These results contradict H3, in which we expected that problem-focused coping would be positively related to perceptions about the robot and that emotion-focused coping would be negatively related to these same perceptions. Instead, results showed no effects of problem-focused coping on perceptions of the robot, and a positive relationship between the emotion-focused coping strategy and the robot's relevance.

Exploratory analyses

Finally, we tested for direct effects of the conditions on the perceptions participants had about the robot. Results from a MANOVA with manipulated emotional state and manipulated coping potential as independent variables showed that both main effects were

not significant (Fs < 1.50, ps > .20). However, the multivariate interaction effect of manipulated emotional state and coping potential did turn out to be significant, Wilk's = .84, $F(9,98) = 2.13$, $p = .034$, $\eta_p^2 = .16$.

Univariate results showed that this multivariate interaction effect was caused by significant effects on perceived realism, $F(1,106) = 6.18$, $p = .014$, $\eta_p^2 = .06$, and perceived intentions to use the robot, $F(1,106) = 4.84$, $p = .030$, $\eta_p^2 = .04$, as well as a marginally significant effect on perceived affordances, $F(1,106) = 3.71$, $p = .057$, $\eta_p^2 = .03$. Descriptive statistics showed that among the sad participants, the ones in the high coping potential condition perceived the robot to have more positive affordances ($M = 3.39$, $SD = .54$), perceived it to be more realistic ($M = 2.52$, $SD = .80$) and had higher intentions to use it ($M = 3.78$, $SD = .82$) compared to the sad participants in the low coping potential condition (respectively $M = 3.17$, $SD = .77$; $M = 1.93$, $SD = .65$; $M = 3.28$, $SD = 1.00$). For angry participants, we found the opposite to be true: Participants in the low coping potential condition perceived more affordances ($M = 3.39$, $SD = .65$), more realism ($M = 2.37$, $SD = .59$) and had higher intentions to use the robot ($M = 3.56$, $SD = .65$) compared to participants in the high coping potential condition ($M = 3.07$, $SD = .93$; $M = 2.22$, $SD = .95$; $M = 3.29$, $SD = 1.07$). These interaction effects are visualized in Figure 4 below.

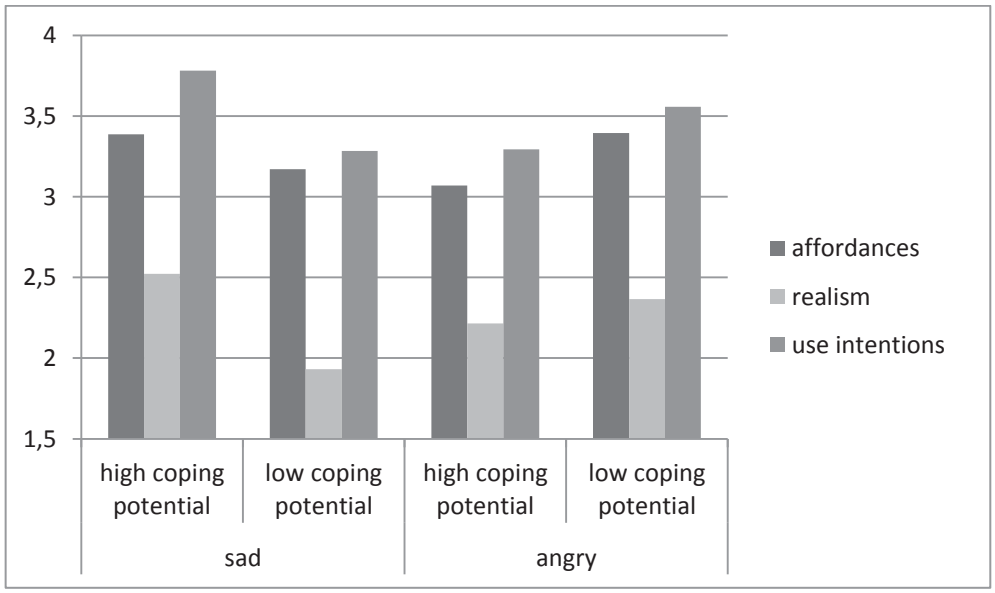

Figure 4. Interaction effects of manipulated emotional state and coping potential on participants' perceptions of the robot's affordances, realism, and intentions to use the robot.

Discussion

The current paper aimed to study the role of emotion and emotional coping in influencing people's perceptions of social robots. Most prior research focused either on emotions after an interaction with a robot, or assessed perceptions of the robot without participants having actually interacted with the robot. In the current studies, we wanted to see how prior (incidental) emotions and related appraisals and coping affected perceptions that participants formed after having interacted with robot Nao/Zora.

In the first study, we did not find the results that were expected based on previous research on the influence of prior emotions on perceptions of robots. We did find the expected differences between emotional state and coping potential conditions in terms of the appraisals and coping strategies associated to each of the conditions, yet we did not find the expected influence of the appraisals or coping strategies on perceptions of the robot. Based on participants' reactions after participation in Study 1, we reasoned that surprise about meeting a robot during the study may have overruled the influence that appraisals and coping strategies may have had on perceptions of the robot. In Study 2, we hoped to rule out surprise as a cause for not being to replicate these earlier results. However, results of this second study also did not provide support for our hypotheses. Even though we did find that our manipulations were effective in achieving different emotional states and different levels of coping potential and these appeared to have an influence on participants' appraisals and coping strategies, results again did *not* show that these appraisals or coping strategies affected the perceptions of the robot in the predicted way.

These results contrast earlier studies (Spekman et al., 2018a; 2018b), which appeared to find that the appraisal of coping potential mediated the effect of emotional state on perceptions of a social robot. Those prior studies differ – among others – from the current studies in the way emotional state was induced. In both earlier studies (Spekman et al., 2018a; 2018b), a recall procedure was used to induce emotions, while the current studies used a scenario method to induce emotion. While the scenarios were extensively pre-tested to check whether they successfully induced the desired emotion, one could argue that there are crucial differences between the two emotion induction methods. The recall procedure asks participants to recall a situation in which they experienced a certain emotion, which ensures that participants experience a personally relevant emotion, whereas

the scenario method may be less personally relevant for the participants, especially if participants are having trouble imagining the particular scenario. Even though the recall procedure is often used in emotion research and ensures personal relevance of the recalled emotion, it has the disadvantage that the emotional state in question may be resolved by the time the situation is recalled (cf. goal-attainment, Lerner & Keltner, 2000). If this is the case, then there is a big chance that the appraisals or coping strategies reported about the emotional situation have been influenced or changed (i.e., one possible coping strategy is cognitive reappraisal; Gross & John, 2003). Perhaps the difference between the two ways to induce emotional state may have caused the findings in the current studies to differ from those in Spekman and colleagues (2018a; 2018b).

As already noted in the introduction, there is another difference between the current studies and earlier studies: The participants in the current studies had an actual interaction with robot Nao/Zora while this was not the case in those earlier studies. In the study by Spekman and colleagues (2018b), participants' perceptions were assessed based on their reading of a newspaper article about a robot, and in Spekman and colleagues (2018a), participants had a 'virtual' interaction with a robot via on-screen videos. In the two studies reported in the current paper, participants talked to robot Nao/Zora which was physically present, standing in front of the participants. It is likely that the physical presence of the robot and experience with the robot may have influenced results, as has been shown to be the case in previous research comparing physical robots to virtual, on-screen versions thereof (e.g., Hoffmann & Krämer, 2013; Jung & Lee, 2004; Powers, Kiesler, Fussell, & Torrey, 2007). In those studies, the physically present robot led to more experienced social presence (Jung & Lee, 2004; Powers et al., 2007), more time spent on the interaction (Powers et al., 2007), and more favorable attitudes/evaluations (Jung & Lee, 2004; Powers et al., 2007) than the virtual on-screen version of the robot. However, none of the robots used in those studies were humanoid robots, which may be the reason why our the current studies' findings do not align with findings from these previous studies. Furthermore, the tasks that participants had to perform in those studies were clearly different from the task in our studies. In our own studies, the task was not so much presented as a task, but rather as a general conversation. This is in clear contrast to the problem-solving and persuasive tasks in earlier studies. As Hoffman and Krämer (2013) showed in their study, the nature of the task can influence people's preference for a robot or

a virtual, on-screen agent (i.e., the virtual agent was preferred for persuasive purposes, whereas the physical robot was preferred for problem-solving tasks). Thus, perhaps the physical presence of the robot in our studies may have resulted in a different process compared to the earlier studies by Spekman and colleagues (2018a; 2018b). Additionally, experience with technology has been found to be a strong moderator of use intentions and actual use of that technology (Venkatesh, Thong, & Xu, 2012). It is thus likely that the physical presence of the robot and actual experience affect the way we perceive robots, and consequently may overrule any emotional effects. More research is needed to say more about the relative contribution of different factors (such as prior emotions and technology experience) in influencing perceptions of social robots in healthcare contexts.

Even though we did not find that appraisals and coping strategies affected the perceptions of the robot as expected, additional analyses did appear to suggest that the interaction of emotional state and coping potential affected some of the perceptions of the robot. This was in contrast to expectations based on the appraisal-tendency approach (Lerner & Keltner, 2000; 2001), which suggested that emotional state may affect future situations via the transfer of emotional appraisals from one situation to another. However, at the same time, this interaction effect of emotion and coping seems to be in line with the approach to coping as suggested by Lazarus (2006). Lazarus (2006) distinguishes two different appraisals for every emotional situation: a primary appraisal (is this situation important and relevant to me?) and a secondary appraisal (what can I do to cope with this situation?). Both these appraisal processes are important in determining how people feel about a situation as well as what actions people undertake to cope with that situation. The results of the current study's additional, exploratory analyses seem to align with this approach by showing that emotional state (i.e., primary appraisal) *only* affects perceptions of the social robot's affordances and use intentions in combination with coping potential (i.e., secondary appraisal) – yet only does so for a limited number of perceptions. This seems to suggest that differences between emotional states on the perceptions of a social robot are contingent upon whether the emotional state is (relatively) easy or hard to cope with.

A point of concern with regard to our studies was the fact that the second study reported here included a relatively high number of male participants compared to Study 1 (25.7% in Study 1 vs. 34.5% in Study 2). Additionally, the general familiarity with robots

in the media as reported by the participants themselves was also higher in Study 2 than in Study 1 (M = 4.68, SD = 2.31 in Study 1 vs. M = 5.34, SD = 1.74 in Study 2). This may have been due to the fact that the second study was advertised as "talking to a robot", as compared to the first study which was advertised as "a study about imagining and dealing with emotional situations", which may have attracted a somewhat different audience to participate in both studies and possibly leading to different expectations about the robot to begin with. These expectations about the robot and it's capabilities may also have interrupted the effects that emotional appraisals or coping may have had on perceptions of the robot, for instance, because the robot did not meet expectations.

The conversation that participants had with robot Nao/Zora were based on the Manchester Short Assessment of Quality of Life questionnaire (MANSA; Priebe et al., 1999). To keep as close to the MANSA questionnaire as possible, the interaction was designed such that it did not allow for deviation from the pre-programmed Likert-type questions. This sometimes led to situations in which participants felt the conversation was unnatural, especially when participants asked questions in return which Nao/Zora did not reply to, or when Nao/Zora interrupted the participants. Yet, the focus of the current study was not on this interaction, but rather on seeing how perceptions of the robot would be influenced by participants' prior emotions. Nevertheless, the 'unnatural' feel of the conversation may have also affected participants' perceptions of the robot, and perhaps interrupted the expected effects of the induced emotions and coping potential.

Related to this is the fact that the nature of the conversation with the robot was inherently artificial due to the research context. Participants were induced with an emotion (the success of which is contingent upon their willingness to engage in the scenario, to begin with), and then could only briefly interact with the robot. In actual healthcare situations, the emotions that patients experience are likely to be much more intense and longer lasting than the ones we induced in our lab, and it is likely that the emotions that we induced faded away fairly quickly, making it difficult to predict what would actually happen in a healthcare situation with more intense and longer lasting emotions, and where people have more opportunity to interact with a robot.

In all, even though it may seem obvious that one's current emotional state would affect how one interacts with a robot, the current studies did not find support for this idea. Interestingly, earlier studies in which the robot was *not* physically present did appear to

lend support for that common sense expectation (albeit via emotional appraisals), so it appeared that the physical presence of the robot makes a big difference. It thus seems as though encountering a physically present social robot appeared to engage an entirely different process, in which prior emotions play a different role. Even though more research is need (especially in the field), the results appear to suggest that the mere presence of a robot may make us forget – at least temporarily – about our emotional problems.

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Appendix 1: Scenarios

Sad condition

(Note: participants were asked first "Is your best friend male or female?", to tailor the scenario)
Today is gonna be a hard day: Saying goodbye to your best friend. It felt like a massive blow to the head when his/her parents called you to tell you s/he passed away. The first day you were very upset and you spent the entire day crying in bed. You will miss him/her and his/her support immensely…

During the farewell service, you look outside. It starts to rain. As if today wasn't sad enough yet. You look around you and see your best friend's parents. They're crying. Your eyes are burning. The hall is packed with family, friends, and fellow students. Some people even have to stand up during the service because there aren't even enough chairs. Your throat hurts. All these people are going to miss him/her so much, just like you… You feel a lump in your throat, and swallow your tears.

Your friend's mother tells a touching story about how funny s/he was as a kid, and how heavy the last period had been to her and her husband. They had asked you to speak too, but you were certain that you would have to cry if you did. And what is there to say anyway? That s/he was so incredibly nice, sweet, and funny? That you will miss him/her so much? It only makes the grief worse…

When you look around, you see that many of the speakers and other people present also have trouble to keep their eyes dry during the speeches. You feel tears filling up your eyes again and try to swallow them away.

After the service, the family walks outside with the coffin. You, and the rest of the people present follow in a procession to the spot where s/he will be buried. Once at the burial site, they hand out flowers. White roses, his/her favorite. Together with friends, you put your roses on the coffin, after which the casket is lower into the grave. You feel cold sweat on your back. The other people also put their roses on the coffin, and slowly people are leaving the cemetery.

You look into the grave. How cold it has to be down there… A shock goes through your body. Your body trembles. You will never see him/her again. You let your tears flow freely…

Easy-to-cope-with (sad condition)

Your friend's passing didn't come as a total surprise. S/he was battling cancer for years, and unfortunately s/he lost the battle a few days ago. You knew it was coming. It was already clear as day when s/he was diagnosed that it would be just a matter of time.

You know that s/he was in a lot of pain, and that s/he suffered tremendously in the last few weeks. Now his/her suffering has ended, and you think this might be for the best.

Hard-to-cope-with (sad condition)

Your friend's passing came as a complete surprise. Last weekend, the two of you and some other friends went out, and the next day you got a phone call from his/her parents. S/he was involved in an accident on the way to university. S/he died instantly…

A guy/girl in the prime of his life, all of sudden s/he was gone. Incredible! Life is so unfair!!!

Anger condition

The last few weeks, you worked really hard on an important course assignment, together with a fellow student. Although… 'together' is somewhat exaggerated… Basically, you did all of the work by yourself, while your fellow student came up with one poor excuse after another.

Immediately when the teacher announced the groups, you heard that he is notorious for freeriding. You wanted to give him the benefit of the doubt, so you immediately sent him an e-mail to ask when he had time to work on the first part of the assignment together. His reply was filled with excuses. He said he had to work all week when we didn't have classes, so he really couldn't find the time this week to work on the assignment together. He suggested you could do the first part this week, and he would make up for that next week.

But of course, that didn't happen in the following week. Nor in the week thereafter. Every single time he had some kind of excuses, and after a lot of drama you did all of the assignments yourself. Fool. You are so done with that guy and don't want to waste any more energy on him. You seriously doubted whether you would put his name on the assignments, and now you regret doing it anyway. You seriously hate yourself for doing this… Fool, fool!

Then you get an e-mail from your teacher that you're the guy your worked together with – yeah right, 'together' – does not agree with the grade you two got (a C) because he claims that *he* did most of the work! And so he feels he is entitled to a higher grade than you! Are you kidding me?!

The teacher suggests, based on his story, that he will get a B, and you will get a D. Aaaargh! Really?! Where does he get the nerves? Your heart pounds and you clench your fists. It's a good thing that guy isn't here right now, because you would've probably seriously injured him. And why does that teacher just assume that his story is true without even hearing your side of the story?! You throw the pens on your desk them across the room and tear that stupid assignment to pieces and throw the pieces across the room as well. Did they go mad?!

Easy-to-cope-with (anger condition):

How is it possible that that teacher just believes that idiot's story no questions asked, while the teacher didn't even ask for your side of the story? Luckily, the grades aren't final yet…

At the bottom of the teacher's e-mail you see a phone number – good! That gives you the opportunity to at least tell your side of the story!

Hard-to-cope-with (anger condition):

How is it possible that that teacher just believes that idiot's story no questions asked, while the teacher didn't even ask for your side of the story? And to make matters worse, it turns out that the teacher has already finalized the grades. Now it's obviously impossible to do something about it…

Appendix 2: pre-test results

In the pre-test, we checked whether the emotional scenarios indeed induced the intended emotion and coping potential among 62 university students.

To assess emotion, we used 4 items to check whether respondents felt angry after reading the story (Cronbach's $\alpha = .95$), 3 items to check whether respondents felt sad after reading the story (Cronbach's $\alpha = .88$), and 9 filler items representing different emotions than anger and sadness. Furthermore, intensity of experienced anger and sadness was measured using a slider (0 = "not angry/sad at all" to 100 = "very angry/sad").

To test whether the two emotional scenarios induced different emotions, a MANOVA was performed with emotional condition as independent variable, and the anger-scale, the sadness-scale, and the filler items as dependent variables. Multivariate effects showed a significant effect, Wilk's $\lambda = .38$, $F(11,50) = 7.29$, $p < .001$, $\eta_p^2 = .62$. Univariate effects showed a significant difference between the two conditions in terms of anger, $F(1,60) = 25.86$, $p < .001$, $\eta_p^2 = .30$, and a marginally significant difference in terms of sadness $F(1,60) = 3.63$, $p = .06$, $\eta_p^2 = .06$. Participants that had read the anger-scenario were thus more angry ($M = 3.05$, $SD = 1.13$) and less sad ($M = 2.24$, $SD = .87$) than participants that had read the sadness-scenario ($M = 1.71$, $SD = .93$ and $M = 2.70$, $SD = 1.04$ respectively). Furthermore, we also found significant yet small differences on filler items 'cheerful' ($F(1,60) = 7.37$, $p = .01$, $\eta_p^2 = .11$) and 'tense' ($F(1,60) = 4.66$, $p = .04$, $\eta_p^2 = .07$;); participants in the anger condition scored somewhat higher on both items than participants in the sadness condition.

Next, we also performed a MANOVA with emotional condition as independent and anger and sadness intensity scores as dependent variables. Multivariate tests showed a significant difference; Wilk's $\lambda = .49$, $F(2,59) = 30.61$, $p < .001$, $\eta_p^2 = .51$. Univariate tests confirmed that, as expected, angry participants scored higher ($M = 61.65$, $SD = 23.78$) on the anger-intensity scale than sad participants ($M = 28.84$, $SD = 25.68$), $F(1,60) = 27.24$, $p < .001$, $\eta_p^2 = .31$. Furthermore, sad participants also were found to score higher on the sadness-intensity scale ($M = 50.19$, $SD = 25.40$) compared to angry participants ($M = 31.32$, $SD = 20.96$), $F(1,60) = 10.18$, $p = .002$, $\eta_p^2 = .15$.

In order to assess coping potential among the respondents, we used 5 items from Spekman et al. (2018a) to assess the appraisal of coping potential (e.g., "I trust that I can

handle this situation"), which together formed a reliable scale (Cronbach's α = .87). We also assessed the closely related appraisals of control (2 items; $R_{\text{Spearman-Brown}}$ = .84), situational agency (2 items; $R_{\text{Spearman-Brown}}$ = .83), other-agency (single item) and self-agency (single item; all items from Spekman et al., 2018a).

To test whether the emotional scenarios differed in terms of coping potential, we performed a MANOVA with coping potential as independent variable and the appraisals as dependent variables. Even though multivariate tests showed no significant results (Wilk's λ = .88, $F(5,56) = 1.52$, p = .20, η_p^2 = .12), we did find a significant yet small univariate effect for coping potential, $F(1,60) = 5.10$, p = .03, η_p^2 = .08. Participants that had read the easy-to-cope-with paragraph appraised their situation as somewhat easier to cope with (M = 3.18, SD = 1.04) compared to participants that had read the hard-to-cope-with paragraph (M = 2.62, SD = .91). Results showed that these coping potential paragraphs did not affect the other appraisals.

To conclude, we found that the emotional scenarios induced the intended emotions, and that the additional paragraph intended to induce coping potential also did just that while not affecting the appraisals of control or agency. Thus, we considered the manipulation successful.

Appendix 3: Overview of scales and items used in study 1 and 2

Table 1. Overview of emotional appraisal items and their PCA scores (using oblique rotation) in study 1[a,b]

Item	Factor 1 (coping potential)	Factor 2 (self-agency/control)	Factor 3 (other-agency)
I trust that I can handle this situation	.904		
I know how I can best deal with this situation	.795		
I think it will be though to deal with this situation[c]	.782		
It is unclear to me how I should handle this situation[c]	.767		
I think I can easily cope with this situation	.740		
The situation is as it is due to circumstances beyond anyone's control		.922	
The situation was caused by circumstances beyond human control		.848	-.307
I myself am responsible for this situation		-.768	
I am convinced that I can change this situation	.379	-.681	
I feel that I can influence this situation	.332	-.632	
Something or someone else than me is responsible for this situation			.926

[a] PCA scores based on the pattern matrix
[b] Scores <.30 are suppressed
[c] Item was reverse-coded

Table 2. Overview of the robot perception measures and their reliabilities in study 1

Scale	Items used in scale	Reliability[b]
Perceived ethics	*I feel that Nao/Zora…* has good intentions, wants the best for me, is malevolent, is mean	.705
Perceived affordances	*I feel that Nao/Zora is…* intelligent, capable, skillful, handy, dumb[a], clumsy[a], incompetent[a]	.806
Perceived aesthetics	*I feel that Nao/Zora…* looks pretty, is unattractive, is ugly, looks nice	.683
Perceived realism	*I feel that Nao/Zora…* appears natural, looks fake, looks real, looks artificial	.663
Perceived relevance	*I feel that Nao/Zora is…* important, useless, useful, worthless	.653
Perceived valence	*I…* have positive expectations about Nao/Zora as a healthcare robot, am reluctant about Nao/Zora in healthcare, expect to be disappointed by Nao/Zora as a healthcare robot, look forward to meet a healthcare robot such as Nao/Zora	.857
Perceived involvement	*I feel…* good about Nao, involved with Nao/Zora, connected to Nao/Zora, it's nice to talk to Nao/Zora	.836
Perceived distance	*I feel…* it's annoying to talk to Nao/Zora, negative about Nao/Zora, that Nao/Zora is remote to me, there's a distance between Nao/Zora and me	.652
Perceived use intentions	*I would…* want to use Nao/Zora more frequently, want to come across Nao/Zora in different places as well, dismiss Nao/Zora next time, ignore Nao/Zora next time	.742

[a] Item dropped from the scale based on results of PCA and reliability analysis.
[b] All reported values are Cronbach's alpha

Table 3. Overview of the robot perception measures and their reliabilities in study 2

Scale	Items used in scale	Reliability[b]
Perceived ethics	*I feel that Nao*/Zora… has good intentions[a], wants the best for me[a], is malevolent, is mean, is trustworthy[a], is dangerous, has questionable intentions[a], is insincere[a], is evil, is reliable[a]	.772
Perceived affordances	*I feel that Nao/Zora is…* intelligent, capable, skillful, handy, dumb[a], clumsy[a], incompetent[a]	.765
Perceived aesthetics	*I feel that Nao/Zora…* looks pretty, is unattractive, is ugly, looks nice, is unpleasant to look at[a], looks horrible[a], could have been designed better[a], could have looked prettier[a]	.670
Perceived realism	*I feel that Nao/Zora…* appears natural, looks fake[a], looks real, looks artificial[a], looks realistic, looks lifelike, looks authentic[a], looks unrealistic[a]	.809
Perceived relevance	*I feel that Nao/Zora is…* important, useless, useful, worthless	.764
Perceived valence	*I…* have positive expectations about Nao/Zora as a healthcare robot, am reluctant about Nao/Zora in healthcare, expect to be disappointed by Nao/Zora as a healthcare robot, look forward to meet a healthcare robot such as Nao/Zora	.883
Perceived involvement	*I feel…* good about Nao/Zora, involved with Nao/Zora, connected to Nao/Zora, it's nice to talk to Nao/Zora	.822
Perceived distance	*I feel…* it's annoying to talk to Nao/Zora [a], negative about Nao/Zora[a], that Nao/Zora is remote to me, there's a distance between Nao/Zora and me, that I am indifferent about Nao/Zora, that Nao/Zora leaves me cold, it's irritating to talk to Nao/Zora[a], I'd rather stay away from robots such as Nao/Zora[a]	.795
Perceived use intentions	*I…* want to use Nao/Zora more frequently, want to come across Nao/Zora in different places as well, would dismiss Nao/Zora next time[a], would ignore Nao/Zora next time[a], wouldn't know what to do with a robot like Nao/Zora, want nothing to do with a robot like Nao/Zora, do not want to see Nao/Zora again[a], have had enough of Nao/Zora[a]	.829

[a] Item dropped from the scale based on results of PCA and reliability analysis.
[b] All reported values are Cronbach's alpha

Table 4. Overview of coping strategy measures and their reliabilities in studies 1 and 2[a]

Scale	Items used in scale	Reliability study 1[b]	Reliability study 2[b]
Problem-focused	*I would…* concentrate my efforts on doing something about the situation, take action to try to make the situation better, try to come up with a strategy about what to do	.814	.793
Support	*I would try to get…* emotional support from others, comfort and understanding from someone, advice or help from other people about what to do, help and advice from other people	.804	.765
Emotion-focused	*I would…* try to see it in a different light to make it seem more positive, try to look for something good in what is happening, accept the reality of the fact that it has happened, learn to live with it	.815	.809
Humor	*I would…* make jokes about it, make fun of the situation	.818	.767
Denial	*I would…* say to myself "this isn't real", refuse to believe that it has happened		
Self-distraction	*I would…* turn to work or other activities to take my mind off things, do something to think about it less such as go to the movies, watching TV, reading, daydreaming, sleeping, or shopping	.713	.768
Substance (ab)use	*I would…* use alcohol or other drugs to make myself feel better, use alcohol or other drugs to help me get through it	.955	.922
Spiritual	*I would…* try to find comfort in my religion or spiritual beliefs, pray or meditate	.851	.902

[a] PCA and reliability analyses showed that 7 items did not really fit any of the above scales, therefore, these 7 items are left out. These 7 items cover, amongst others, Carver's (1997) subscales 'Venting', 'Behavioral disengagement', and 'Self-blame'.
[b] All reported values are Cronbach's alpha

Appendix 4: Overview results H1, step 1 (Study 1)

In the first MANOVA analysis, we found significant multivariate effects for manipulated emotional state, Wilk's $\lambda = .19$, $F(5,84) = 73.28$, $p < .001$, $\eta_p^2 = .81$, for manipulated coping potential, Wilk's $\lambda = .72$, $F(5,84) = 6.54$, $p < .001$, $\eta_p^2 = .28$, as well as for the interaction of both factors, Wilk's $\lambda = .76$, $F(5,84) = 5.30$, $p < .001$, $\eta_p^2 = .24$.

Univariate effects for manipulated emotional state showed significant effects on all appraisals (all *p*s $< .001$, $\eta_p^2 > .35$) except other-agency (*ns*). Specifically, sad participants appraised the situation as harder to cope with, harder to control, having more situational agency and having less self-agency than angry participants (see Table 1 below).

Table 1. Means (*M*) and standard deviations (*SD*) for sad (n = 46) and angry participants (n = 46) on the appraisals of coping potential, control, situational agency, and self-agency.

	Sad participants		**Angry participants**	
	M	*SD*	*M*	*SD*
Coping potential	2.23	.75	3.33	.89
Control	1.77	.77	3.92	.95
Situational agency	3.79	1.00	1.48	.61
Self-agency	1.37	.77	3.00	1.17

For manipulated coping potential, univariate tests showed significant effects on all appraisals (all *p*s $\leq .002$, $\eta_p^2 > .09$) except self-agency (*ns*). Participants who had read the easy-to-cope-with scenario appraised their situation as easier to cope with and easier to control than did participants who had read the hard-to-cope-with scenario. Furthermore, participants in the easy-to-cope-with condition appraised more situational agency and less other-agency compared to participants in the hard-to-cope-with condition (see Table 2 below).

Table 2. Means (*M*) and standard deviations (*SD*) for participants in the easy-to-cope-with (n = 49) and hard-to-cope-with conditions (n = 43) on the appraisals of coping potential, control, situational agency, and other-agency.

	Easy-to-cope-with		**Hard-to-cope-with**	
	M	*SD*	*M*	*SD*
Coping potential	2.97	1.01	2.56	.92
Control	2.98	1.52	2.70	1.21
Situational agency	3.00	1.57	2.22	1.13
Other-agency	2.39	1.40	3.30	1.12

For the interaction of manipulated emotional state and coping potential, we found significant effects on the appraisal of control, $F(1,88) = 10.89$, $p = .001$, $\eta_p^2 = .11$, and the

appraisal of situational agency, $F(1,88) = 16.91$, $p < .001$, $\eta_p^2 = .16$. Within the participants that had read the sad emotional scenario, we did not find a big difference between the easy-to-cope-with and the hard-to-cope-with conditions in terms of control; both appraised themselves to have relatively little control in the situation ($M = 1.76$, $SD = .76$ and $M = 1.79$, $SD = .79$ respectively). Within the angry condition, however, we found a bigger difference: Participants that had read the easy-to-cope-with scenario appraised much more personal control of their situation ($M = 4.48$, $SD = 3.42$) compared to participants that had read the hard-to-cope-with scenario ($M = 3.42$, $SD = .97$). For the appraisal of situational agency, a reverse pattern was found. Angry participants appraised relatively little situational agency, regardless of whether they had read the easy-to-cope-with ($M = 1.43$, $SD = .60$) or the hard-to-cope-with scenario ($M = 1.52$, $SD = .63$). The difference was larger amongst the sad participants: Those in the easy-to-cope-with condition appraised much more situational agency ($M = 4.28$, $SD = .68$) than those in the hard-to-cope-with condition ($M = 3.11$, $SD = .99$).

Appendix 5: Overview results H1, step 1 (Study 2)

The MANOVA showed significant multivariate effects for manipulated emotional state, Wilk's $\lambda = .24$, $F(5,102) = 65.53$, $p < .001$, $\eta_p^2 = .76$, for manipulated coping potential, Wilk's $\lambda = .78$, $F(5,102) = 5.73$, $p < .001$, $\eta_p^2 = .22$, as well as for the interaction of both factors, Wilk's $\lambda = .87$, $F(5,102) = 3.13$, $p = .01$, $\eta_p^2 = .13$.

For manipulated emotional state we found that the univariate effects were similar to those in Study 1. Significant differences were found between the sad and angry participants in terms of all appraisals (all *p*s <.001, $\eta_p^2 \geq .23$) except for the appraisal of other-agency (*ns*). Sad participants appraised their situation as harder to cope with, harder to control, having more situational agency and having less self-agency compared to angry participants (see Table 3 below).

Table 3. Means (*M*) and standard deviations (*SD*) for sad (n = 55) and angry participants (n = 55) on the appraisals of coping potential, control, situational agency, and self-agency.

	Sad participants		**Angry participants**	
	M	*SD*	*M*	*SD*
Coping potential	2.48	.70	3.49	.85
Control	2.20	.91	4.07	.68
Situational agency	3.73	1.12	1.45	.68
Self-agency	1.55	.90	2.71	1.21

Univariate effects for manipulation coping potential showed significant effects on appraised coping potential, $F(1,106) = 22.01$, $p < .001$, $\eta_p^2 = .17$, and appraised situational agency, $F(1,106) = 5.83$, $p = .02$, $\eta_p^2 = .05$. No differences were found between the coping potential conditions in terms of appraised control, other-agency, and self-agency (all three *ns*). Specifically, participants who had read the easy-to-cope-with scenario were found to appraise their situation as easier to cope with and having more situational agency than participants who had read the hard-to-cope-with scenario (see Table 4 below).

Table 4. Means (*M*) and standard deviations (*SD*) for participants in the easy-to-cope-with (n = 62) and hard-to-cope-with conditions (n = 48) on the appraisals of coping potential and situational agency.

	Easy-to-cope-with		**Hard-to-cope-with**	
	M	*SD*	*M*	*SD*
Coping potential	3.23	.90	2.66	.87
Situational agency	2.84	1.62	2.27	1.18

For the interaction of manipulated emotional state and coping potential, we found significant effects on the appraisal of situational agency, $F(1,106) = 7.33$, $p < .01$, $\eta_p^2 = .07$, and the appraisal of other-agency, $F(1,106) = 6.95$, $p = .01$, $\eta_p^2 = .06$. Within the participants that had read the sad emotional scenario, we found that the participants in the easy-to-cope-with condition appraised their situation as having more situational agency ($M = 4.08$, $SD = 1.13$) than the hard-to-cope-with condition ($M = 3.20$, $SD = .90$). Within the angry condition, however, we found that there was not much of a difference between participants in the easy-to-cope-with ($M = 1.43$, $SD = .66$) and those in the hard-to-cope-with conditions ($M = 1.48$, $SD = .71$). For the appraisal of other-agency, we found that angry participants also did not differ much (easy-to-cope-with: $M = 3.48$, $SD = .99$; hard-to-cope-with: $M = 3.19$, $SD = 1.39$), while the difference was somewhat bigger (and reversed) amongst participants in the sad condition (easy-to-cope-with: $M = 2.52$, $SD = 1.46$; hard-to-cope-with: $M = 3.55$, $SD = 1.30$).