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Germ-Free Robotic Friends: Loneliness during the COVID-19 Pandemic Enhanced the Willingness to Self-Disclose towards Robots

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Abstract: During the COVID-19 pandemic, many people felt lonely. Social robots may serve to alleviate such feelings of social disconnection. Prior research pointed out that lonely or socially excluded individuals were particularly willing to interact with social robots, because they tend to anthropomorphize robots. Such anthropomorphization may facilitate deeming robots suitable as social interaction partners. To extend existing research on the role of social robots for lonely people, we examined the effect of inclusionary status (i.e., inclusion vs. exclusion vs. control) on mind perception, perceived warmth, and participants' willingness to self-disclose towards a social robot. We hypothesized that social exclusion would increase mind perception, perceived warmth, and participants' willingness to self-disclose towards a social robot. Above and beyond, we assessed self-reported loneliness during and before the COVID-19 pandemic. Whereas inclusionary status had no effect on the dependent variables, correlational analyses revealed that the more COVID-19-induced loneliness participants experienced, the more they were willing to self-disclose towards a robot. Likewise, these individuals attributed more mind agency to the robot and reported to look forward to a conversation with the robot. Summing up, people who experience situational loneliness may be particularly prone to accept social robots as social interaction partners.

Keywords: self-disclosure; loneliness; exclusion; social robot; COVID-19 pandemic; anthropomorphization; mind attribution

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1. Introduction

The COVID-19 pandemic has challenged people worldwide, not only in terms of catalysing physical health issues, but also mental health issues. From 2020 onwards, various restrictions were put in place across the globe to fight the pandemic. These included social distancing policies or self-quarantining. Such measures, however, came with psychological costs. To illustrate, Zacher and Rudolph [1] documented the psychological impact of the COVID-19 pandemic in the German context. For instance, German people's life satisfaction and positive affect significantly decreased between March and May 2020. The experience of loneliness is one major consequence of the pandemic due to social distancing policies [2]. Anecdotally, the term "loneliness pandemic" has emerged from this observation [3]. Being socially disconnected raises mental health issues because humans are inherently social, longing for social contact and interactions [4]. This is captured by the construct *need to belong*, which reflects the motivation to build and sustain enduring interpersonal relationships [4]. If this psychological need is frustrated, people experience loneliness or even more severe affective states, including anxiety and depression [4]. Correlations between loneliness and various mental health-related variables, e.g., stress, anxiety, and depression, were also observed in research that shed light on the impact of the COVID-19 pandemic [5]. Not

surprisingly, people searched for measures to reduce loneliness during the pandemic [6]. Unfortunately, social distancing policies have excluded face-to-face measures to mitigate loneliness. Thus, alternatives to real-life human–human interactions are called for. In fact, which strategies do people actually use to cope with the experience of loneliness and social disconnection? To reflect on these strategies, we will review some key theoretical frameworks.

First, the Belonging Regulation Model [7–9] assumes that a threat to the need to belong, e.g., by means of loneliness or social rejection, activates a social monitoring system, followed by an attempt to restore this need by increasing attention to social cues (e.g., by checking the affective state of our interaction partners). Increased attention to social cues represents a potential prerequisite to social success because this information helps us behave in a socially acceptable manner [10]. Additionally, research on social reconnection strategies showed that social exclusion increased the motivation to build a new social bond with so-far-unknown other individuals [11]. Moreover, people search for alternative communication channels to compensate for a lack of face-to-face social contact. For example, previous research has shown that lonely people turn to social media use to connect with others [12]. Taken together, people try to maintain social connection and react sensibly to threats to social connection; they increase efforts to keep social bonds and try to identify alternative opportunities to connect with others. During the COVID-19 pandemic, such coping strategies have become crucial to assure individual wellbeing. Here, we focus on one specific behaviour that serves this purpose: Self-disclosure.

Self-disclosure can be defined as the verbal sharing of information about oneself to another person [13]. Theoretical considerations as well as empirical findings support the idea that self-disclosure can be used to connect with others. Consequently, self-disclosure eventually helps people to fulfil their need to belong. Relatedly, Social Penetration Theory [14] proposed that self-disclosure is closely tied to relationship development. Accordingly, relationships develop because people gradually share more and more personal information, so that self-disclosures become increasingly intimate the closer the relationship becomes, and vice versa. This is due to the fact that people talk more in depth and comprehensively about personal topics. Moreover, liking and self-disclosure are closely linked [15]. Finally, self-disclosure elicits interpersonal closeness [16], and therefore may serve to satisfy the human need to belong. More recently, the positive relationship between disclosure intimacy and the experience of social connection was also observed in the context of private messages on social networking sites [17]. Self-disclosure does not only communicate personal content; it also informs about relationship quality between the discloser and the recipient [15]. For example, self-disclosure implies that the communicator trusts that the recipient will respond appropriately to the message [18]. Even excessive smartphone use—which is commonly associated with higher levels of stress—reduces loneliness and stress when it is used to self-disclose [19]. In general, self-disclosure is negatively correlated with loneliness [20] and potentially reduces it [21]. However, at the same time, loneliness is positively associated with self-disclosure on social networking sites [22], which might represent an attempt to restore the need to belong via alternative communication channels. Usually, individuals decide to approach or avoid others based on evaluations of others [23,24]. Self-disclosure can be viewed as an approach behaviour, given that relationship development and liking are strongly associated with it [14,15]. Thus, evaluations of others might facilitate or inhibit self-disclosure. Warmth represents a core dimension for evaluating others and for interpersonal connection: Attributing warmth catalyses prosocial behaviour, e.g., helping, and is associated with perceiving good intentions in others [25]. Moreover, perceived social warmth is related to the intention to intensify new social bonds [26]. Thus, warmth attributions represent an additional facet to explain approach behaviour, e.g., self-disclosure towards humans. However, the role of perceived warmth and self-disclosure in the context of seeking connection with nonhuman entities, e.g., robots, remains unclear.

It might be plausible that robots represent a feasible option to remedy social disconnection.

This notion is based on the idea that even nonhuman entities such as pets and robots can reduce loneliness [27,28]. Social robots may create an illusion of social connection [29]. Thereby, the human need to belong might already be satisfied for some people [29]. Even though the creation of such an illusion is ethically problematic, human-robot relationships also come with advantages: Compared to their human counterparts, robots are indeed less demanding, they behave less badly (e.g., they do not cheat), they are more predictable, and they are less judgmental than humans [29]. Moreover, social robots could be deployed during the COVID-19 pandemic while social distancing policies are in place [6,30]. For instance, qualitative data suggest that the robot Vector helped to reduce loneliness during the COVID-19 pandemic [30]. Despite their clear potential in times of a global pandemic, would people in fact turn to robots as social companions?

Previous research has shown that people are reluctant to socially connect with robots [31,32]. However, other work suggests that people are more eager to accept nonhuman entities such as robots as social interaction partners when they feel lonely or excluded [33,34]. This feeling of loneliness and exclusion has likely been experienced by a lot of people during the COVID-19 pandemic [2]. Consequently, social robots represent an increasingly more viable alternative to engage in social interaction when no human interaction partners are available. However, in fact, perceiving social robots as suitable social interaction partners might require the attribution of mental capacities.

1.1. Loneliness and Mental State Attribution

Attributing humanlike mental states and personality characteristics to nonhuman entities, i.e., anthropomorphization [35], may serve as a coping strategy to satisfy the need to belong [33]. When the attribution of mental states is considered in human-robot interaction (HRI) research, mind attribution is usually measured [36]. Typically, two dimensions of mind are considered: Agency and experience [36]. Whereas agency includes capacities such as self-control, planning, morality, and communication, experience encompasses capacities such as feeling pain, pleasure, desire, and fear [36]. Ascribing agency and experience to nonhuman entities allows lonely people to socially connect with them [33]. Regarding robots, Eyssel and Reich [34] have demonstrated that participants attributed more mental capacities and essentially human personality traits to a humanoid robot when remembering a scenario in which they experienced loneliness or social exclusion (vs. a neutral episode). The attribution of mental states is tightly knit to robots' perception as humanlike, facilitating social connection and HRI. It is plausible that individuals who suffer from social disconnection would not only benefit more from contact with nonhuman entities than socially connected individuals, but it is likely that these individuals would also be more willing to engage with nonhuman entities. However, the literature on loneliness suggests that there are at least two types of loneliness, and the particular type of loneliness elicits specific forms of responses to a lack of social connection.

1.2. Situational Loneliness, Chronic Loneliness, and Social Exclusion

Existing literature commonly differentiates between situational loneliness and chronic loneliness [37]. Chronic loneliness represents a rather stable state of unsatisfying social relationships [38]. In contrast, situational loneliness is commonly experienced after stressful life events that require short-term coping [38]. These two types of loneliness are defined by distinct causes: Specific circumstances, such as going through a divorce, or social distancing to counteract the COVID-19 pandemic, pave the way for situational loneliness, whereas personal vulnerabilities, such as a lack of social skills, facilitate chronic loneliness [37,39]. Besides struggling with a lack of social skills, chronically lonely people often experience destructive cognitions and a negative view of other people. These characteristics also prevent them from reconnecting with others [39–41]. Furthermore,

negative social expectations of chronically lonely people may cause behaviours in others that confirm these negative expectations [41]. Thus, chronically lonely people are less capable of developing and maintaining satisfying relationships over the years. In contrast, situationally lonely people use strategies to reconnect, e.g., seeking for a smaller physical distance to other people [37]. Taken together, situationally lonely people are rather eager to reconnect, while chronically lonely people show reduced reconnection behaviours. If this behaviour in human-human interaction is transferable to HRI, chronically lonely people would react more negatively to a social connection opportunity with a social robot than situationally lonely people. Hence, it is important to consider the distinct impact of situational loneliness versus chronic loneliness in HRI research.

Another distinction should be made between social exclusion and loneliness. While loneliness can be caused by situational aspects [37,39], social exclusion itself can be viewed as a situation in which the need to belong is unfulfilled, e.g., because an individual is ignored, avoided, or ostracized by others [42,43]. People facilitate social exclusion through behaviour or traits that are viewed as inappropriate and undesirable by others [44]. In particular, low self-regulation could cause social exclusion because it results in socially undesirable behaviours, e.g., acting selfish. However, in experimental research on social exclusion participants usually experience social exclusion independently from own characteristics and behaviours [11]. As socially excluded people show behaviour which facilitates social reconnection [11], the reaction to social exclusion more closely resembles the behaviour of situationally lonely people, but not the behaviour of chronically lonely people.

1.3. The Current Experiment

To our knowledge, the present research is the first to focus on the relationship between social exclusion, loneliness, and self-disclosure towards a humanoid robot. The primary aim of the present research is to examine the impact of inclusionary status, i.e., feeling included vs. excluded, on the willingness to self-disclose towards a humanoid robot. Our experiment extends previous research by Eyssel and Reich [34] which primarily focused on mind perception. The present research might have practical implications for the use and design of companion robots: If people with an unfulfilled need to belong are more willing to self-disclose towards a robot, companion robots should be designed with functions and behaviours that accommodate this desire to connect and communicate, for instance, by implementing verbal communication skills and conversational behaviours in order to meet user expectations. To date, not all companion robots are equipped with verbal communication skills. For instance, think of Paro, the baby seal robot that is a prominent example of a nonverbal robot [45]. We also considered the attribution of warmth as relevant because the extent to which we deem a person or entity as psychologically warm potentially determines subsequent approach or avoidance reactions [25,26,46]. Thus, we added warmth as a dependent variable. In the present research, we adapted the experimental manipulation used in [34] by focusing on a situation of social exclusion in the instruction given to the participants. On top of that, we added an inclusion condition. Here, participants had to remember a positive situation with a close person, which should increase feelings of being socially connected [47]. These changes led to a between-subjects design with three groups to manipulate inclusionary status (exclusion, inclusion, and control). To differentiate between situational and chronic loneliness, we assessed pre-pandemic loneliness and current loneliness during the pandemic. We subtracted pre-pandemic loneliness from current loneliness to measure changes in loneliness. We used a picture of the robot NAO (Aldebaran) as an exemplary humanoid robot and asked participants to imagine a conversation with the robot NAO.

The hypotheses were as follows:

Hypothesis 1.1: *Participants in the exclusion condition are more willing to engage in self-disclosure (a) in comparison to participants in the inclusion condition and (b) in comparison to participants in the control group.*

Hypothesis 1.2: *Participants in the exclusion condition indicate a more intimate conversation (a) in comparison to participants in the inclusion condition and (b) in comparison to participants in the control group.*

Hypothesis 2: *Participants in the exclusion condition attribute more warmth to the humanoid robot (a) in comparison to participants in the inclusion condition and (b) in comparison to participants in the control group.*

Hypothesis 3: *Participants in the exclusion condition attribute more agency to the humanoid robot (a) in comparison to participants in the inclusion condition and (b) in comparison to participants in the control group.*

Hypothesis 4: *Participants in the exclusion condition attribute more experience to the humanoid robot (a) in comparison to participants in the inclusion condition and (b) in comparison to participants in the control group.*

For exploratory purposes, the effect of the inclusionary status on further variables was examined, i.e., the intimacy of a conversation topic, the number of named conversation topics, the preferred length of a conversation, perceived competence of the humanoid robot and how much people looked forward to a conversation with the robot, i.e., anticipation, in addition to the main dependent variables. These exploratory analyses are reported in the Supplementary Material. However, we report correlations of these further variables in this article. Several covariates (e.g., positive and negative affect [48], technology commitment [49] and social anxiety [50]) were considered for the analysis, which will only be reported in the Supplementary Material to focus on the main results here. In the Supplementary Material, we further compared results regarding positive and negative affect with previous studies which investigated social exclusion as well as positive and negative affect [51].

2. Method

2.1. Participants and Design

We preregistered (https://aspredicted.org/mt7k7.pdf (accessed on 31 October 2022)) the experiment as follows: A sample size of at least 129 valid datasets was needed to achieve 95% power based on an a priori power analysis with G*Power [52]. The power analysis was conducted on the basis of a small-to-moderate effect size for a multivariate analysis of variance (MANOVA) for the inclusionary status (three conditions; $f^2 = .10$) [53] as between-subjects factor on the five main dependent variables (self-disclosure, preferred conversation intimacy, perceived warmth, perceived agency, perceived experience), with an $\alpha = .05$. Based on this power analysis, it was decided that at least 43 valid datasets per condition should be reached before stopping data collection.

We recruited participants via online advertisement on social media to participate in two short ostensibly unrelated online studies during the period from 23 April to 12 May 2020. Following the exclusion criteria outlined in the preregistration, 112 participants had to be excluded from analyses. The final sample thus comprised 138 participants, who were between 18 and 67 years old (M_{age} = 29.39, SD_{age} = 12.39; 93 female, 44 male, one open declaration). A total of n = 43 individuals were randomly assigned to the exclusion condition, n = 47 participated in the inclusion condition and n = 48 individuals were in the control condition. In the exclusion condition, participants were on average 31 years old (M_{age} = 30.77, SD_{age} = 13.79, 13 male, 30 female), whereas in the inclusion condition (M_{age} = 28.46, SD_{age} = 10.88, 13 male, 33 female, one open declaration) and in the control condition

(M_{age} = 28.48, SD_{age} = 11.95, 18 male, 30 female), participants were slightly younger. In the final sample, 128 participants indicated German as native language, 9 participants had a second or other native language but still could speak German fluently, and 1 participant did not indicate information about German language skills. A total of 81 participants were university students, 42 were employed, 14 participants named another occupation, and 1 participant did not answer to this measure. Participants indicated a very low familiarity of the robot NAO (M = 0.47, SD = 1.31 on a scale from 0-7). Most participants (n = 117) did not know the robot NAO at all, 19 participants indicated to know the robot NAO to some degree, and 2 participants did not respond to this measure. The study took approximately 25 min. Participants could gain course credit or participate in a lottery of four BestChoice shopping gift cards worth EUR 10 each. This research was approved by the Ethics Review Board at Bielefeld University (application no. EUB 2019-262).

2.2. Experimental Manipulation

In the exclusion manipulation, participants were instructed to recall and write down a situation in which they were socially excluded (adapted from [34], originally from [11]). To induce feelings of inclusion, participants were asked to recall and write down a situation in which they had a pleasant time with a close person, adapted from a daydreaming task to reduce loneliness [47]. The control condition consisted of a recall task that asked participants to reiterate and write down what they did on the previous day [34].

2.3. Procedure

First, participants gave informed consent to participate in two allegedly separate online studies that tapped recall and mood (Study 1) and revolved around the perception of modern technologies (Study 2). Then, participants were randomly assigned to one of the three experimental conditions to manipulate their inclusionary status. Participants reported affect and perceived social exclusion and then went on to complete the ostensible Study 2. Here, they were presented with a picture of the humanoid robot NAO that was accompanied by a short description of the robot. Participants were instructed to imagine a conversation with NAO and had to rate the imagined conversation and the robot. Additionally, they were asked about personal characteristics (e.g., loneliness). Afterwards, participants were thanked and debriefed. Finally, they had the option to request data deletion and to receive a second recall task to make them feel connected if they felt uneasy due to the exclusion recall task, and then were dismissed.

2.4. Measures

Questionnaire items were formulated in such way that they explicitly referred to the humanoid robot NAO (Aldebaran), of which a picture was presented before participants answered to the measures. Participants' responses were recorded using 7-point Likert scales, except with regard to loneliness. Here, we used 4-point Likert scales, ranging from 1 *never* to 4 *often*. Regarding prior experience with the robot NAO, the response format ranged from 0 to 7 to differentiate between people who did not know NAO at all (0) and those who actually knew NAO but not well after all (1). If necessary, items were recoded so that high scores indicated strong endorsement of the respective construct. Means of the scales were used for analyses. Cronbach's α was used to report internal consistency reliability.

2.4.1. Manipulation Check

Feeling of Exclusion. Six self-generated items measured the degree to which participants felt excluded during the recall task (e.g., "socially isolated", α = .92).

Positive and Negative Affect. Five items assessed participants' positive and negative affect, respectively [48]. Participants were asked how they felt during the recall task. The items regarding feelings of exclusion were mixed in the items of positive and negative

affect to obscure the research question. As positive and negative affect were not part of the research question, we did not report results regarding these variables in this article, but in the Supplementary Material.

2.4.2. Main Dependent Measures

Willingness to Self-Disclose. To assess willingness to self-disclose, sixteen topics related to self-disclosure (e.g., "music I like") were presented with the request to indicate how willing participants were to talk about the topics (α = .96) in the imagined conversation with the NAO robot. This self-generated self-disclosure scale [54] adapts and extends the self-disclosure index [55]. This self-disclosure scale encompasses eight topics low in intimacy (α = .92), four positive topics high in intimacy (α = .88), and four negative topics high in intimacy (α = .91).

Preferred Conversation Intimacy. Additionally, one item assessed the preferred conversation intimacy of the imagined conversation with the robot NAO, with an intimate conversation meaning talking about topics which they usually discuss only with close persons, on a scale from 1 not at all intimate to 7 very intimate.

Warmth. Participants judged the robot on seven warmth-related traits (e.g., "affable"; α = .87) [56–58].

Mind Attribution. Participants rated the robot on six items tapping agency (e.g., "I think the robot NAO can make plans and work towards a goal"; α = .69), and experience (e.g., "I think the robot NAO can be afraid or fearful."; α = .82) [36,59,60], respectively.

2.4.3. Additional Qualitative Measures

Number of Conversation Topics. The number of spontaneously named conversation topics was counted by the two independent raters. If two topics seemed similar, but still separable in content, they were rated as two independent topics. Both raters completely agreed in this measure.

Perceived Intimacy of the Conversation Topic. Two independent raters assessed the intimacy of the conversation topics that participants had proposed for a conversation with the robot on a scale from 1 to 7. The interrater reliability of this rating was assessed using the two-way random intraclass correlation coefficient (ICC) with two raters, ICC (2, 2) = .928, 95% CI [.899, .949]. This ICC value can be interpreted as good-to-excellent interrater agreement [61]. If more than one topic was stated, the mean rating of the most intimate rated topic was used for analysis.

2.4.4. Additional Quantitative Measures

Loneliness. Current loneliness (α = .78) and self-reported pre-pandemic loneliness (i.e., before social distancing policies due to the COVID-19 pandemic were introduced; α = .78), were measured with three items, respectively (e.g., "how often do [did] you feel that you lack companionship?") [62]. The responses were given on a four-point Likert scale ranging between 1 never, 2 rarely, 3 sometimes, and 4 often. The current loneliness index could be interpreted as a result of a general loneliness level combined with COVID-19 pandemic-induced loneliness. The pre-pandemic loneliness might reflect rather stable loneliness. To form a situational loneliness score to capture self-reported loneliness induced by the COVID-19 pandemic, we computed a difference score for current and pre-pandemic loneliness, which we named situational loneliness. We did so by subtracting mean pre-pandemic loneliness scores from mean current loneliness scores. The empirical range for situational loneliness was −3 to 3, given that pre-pandemic and current loneliness could take on a minimum score of 1 and maximum value of 4. Positive situational loneliness scores indicate more current loneliness compared to pre-pandemic loneliness. Negative situational loneliness scores, in turn, indicate less current loneliness compared to pre-pandemic loneliness. We expect the change from pre-pandemic loneliness to current loneliness to be mainly caused by the COVID-19 pandemic, reflecting

situational loneliness. Pre-pandemic loneliness, on the other hand, should be less influenced by COVID-19-related circumstances, as no social distancing policies were active before the onset of the pandemic. Thus, pre-pandemic loneliness most likely reflects chronic loneliness. In contrast, current loneliness might be caused by a combination of the prior loneliness level and loneliness through the COVID-19 pandemic.

Length of the Conversation. Two self-generated items measured subjective preferred length of the conversation with the robot (from as short as possible to as long as possible) and objective preferred length of the conversation with the robot (in minutes).

Anticipation. Participants evaluated their positive anticipation of the conversation with the robot on three self-generated items (e.g., "I would look forward to a conversation with the robot NAO"; $\alpha = .91$).

Competence. Participants judged the robot on seven competence-related traits (e.g., "self-confident"; $\alpha = .77$), [56–58].

Knowing NAO. First, participants indicated if they knew the robot NAO (1 yes, 2 no). If they indicated to know the robot NAO, they were asked how well they knew the robot on a scale from 1 not at all well to 7 very well. To form a single variable, those who did not know the robot NAO at all according to the first variable were coded as a 0 within the second variable, so that the scale ranged from 0 to 7.

3. Results

3.1. Preliminary Analyses

As a manipulation check, we conducted an analysis of variance (ANOVA) with inclusionary status as independent variable and perceived exclusion as dependent variable. Tukey post-hoc tests were reported when the assumption of homogeneity of variances was met, as determined by Levene's test of homogeneity of variance ($p > .05$). If variances were not homogeneous, a Games-Howell post hoc test was used. As predicted, a main effect of inclusionary status emerged, $F(2, 135) = 119.88$, $p < .001$; $\eta_p^2 = .64$. Participants in the exclusion condition reported feeling more excluded ($M = 4.98$, $SD = 1.21$) than participants in the control condition ($M = 2.68$, $SD = 1.05$, $p < .001$, $d = 2.03$), and also more excluded than participants in the inclusion condition ($M = 1.66$, $SD = 0.82$, $p < .001$, $d = 3.24$). Moreover, participants in the inclusion condition reported a significantly lower feeling of exclusion ($M = 1.66$, $SD = 0.82$) compared to the control condition ($M = 2.68$, $SD = 1.05$, $p < .001$, $d = 1.08$). Taken together, the experimental manipulation successfully induced differing stages of exclusion feelings between conditions.

We conducted a t-test to test if people reported more loneliness during the time when social distancing policies due to the COVID-19 pandemic applied compared to the pre-pandemic loneliness experienced before these policies. Participants reported more loneliness while social distancing regulations were active ($M = 2.54$, $SD = 0.74$) than before the policies were in place ($M = 2.15$, $SD = 0.71$, $t(137) = 5.89$, $p < .001$, $d = 0.49$). The two loneliness measures correlated moderately: $r(136) = .44$, $p < .001$. Overall, 13.8% of participants revealed feeling less lonely compared to before the COVID-19 pandemic, and 31.9% did not indicate any change in loneliness. However, more than half of the participants (54.3%) reported feeling more lonely during the COVID-19 pandemic than before the COVID-19 pandemic.

3.2. Main Analysis

To test whether participants in the exclusion condition would indicate more willingness to self-disclose, would indicate a more intimate conversation, and would attribute more warmth and mind to the robot NAO compared to participants in the inclusion and control condition, a multivariate analysis of variance (MANOVA) on the key dependent variables was computed, with inclusionary status serving as an independent variable. Overall, inclusionary status had no effect on willingness to self-disclose, preferred conversation intimacy, perceived warmth, perceived agency, and

perceived experience, Wilk's Λ = .961, $F(10, 262) = 0.52$, p = .874, η_p^2 = .02. Univariate analyses of variance revealed that neither the willingness to self-disclose ($F(2, 135) = 0.03$, p = .970, η_p^2 = .00) nor the self-assessed conversation intimacy ($F(2, 135) = 0.33$, p = .721, η_p^2 = .01) were affected by the inclusionary status. Contrary to our hypotheses, inclusionary status had no effect on perceived warmth ($F(2, 135) = 0.13$, p = .883, η_p^2 = .00). Furthermore, we observed no effect of the inclusionary status on perceived experience ($F(2, 135) = 0.66$, p = .516, η_p^2 = .01) and perceived agency ($F(2, 135) = 0.63$, p = .535, η_p^2 = .01). Descriptive statistics of the main dependent variables are depicted in Table 1.

Table 1. Descriptive statistics of the main dependent variables in each condition.

	Exclusion	**Inclusion**	**Control**
Dependent Variable	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Self-Disclosure	4.74 (1.39)	4.67 (1.45)	4.73 (1.33)
Conversation Intimacy	4.00 (1.93)	3.91 (1.94)	3.69 (1.88)
Warmth	4.86 (0.97)	4.79 (1.21)	4.75 (1.09)
Agency	4.14 (1.05)	4.40 (1.09)	4.26 (1.17)
Experience	2.38 (1.05)	2.59 (1.04)	2.36 (1.13)

Note. Participants only imagined a conversation; no human–robot interaction took place.

3.3. Exploratory Analyses

We conducted correlational analyses to explore the relationship between current loneliness, pre-pandemic loneliness, situational loneliness (change in loneliness likely due to the social distancing policies during the COVID-19 pandemic), and perceived exclusion with our dependent measures (see Table 2). As the correlational analysis shows (see Table 2), only situational loneliness was positively correlated with the overall willingness to self-disclose ($r(136) = .18$, p = .032), with the willingness to self-disclose topics low in intimacy towards the robot ($r(136) = .25$, p = .003), with the pleasant anticipation of a conversation with the robot ($r(136) = .28$, p = .001), and with the preferred subjective length of the conversation ($r(136) = .23$, p = .006). Furthermore, situational loneliness was positively correlated with perceived agency ($r(136) = .22$, p = .009). These results suggest that people who felt more lonely during the COVID-19 pandemic compared to before the pandemic were more willing to talk about personal topics with the robot, especially about self-disclosure topics low in intimacy. Furthermore, they looked more forward towards a conversation with the robot; wanted to talk longer with the robot; and attributed more cognitive abilities to think and plan to the robot. Current loneliness only correlated positively with the attribution of agency ($r(136) = .19$, p = .028), and with topic intimacy ($r(136) = .20$, p = .017). Thus, participants who reported high levels of current loneliness also attributed more cognitive capacities to the robot, and indicated more intimate conversation topics for a human-robot conversation. Similarly, feeling excluded only correlated positively with the objective length of a conversation indicated in minutes ($r(136) = .20$, p = .017). That is, individuals who reported higher levels of exclusion during the recall task also wanted to spend more time conversing with the robot NAO. In contrast, pre-pandemic loneliness correlated negatively with warmth attributions to the robot ($r(136) = -.20$, p = .020), positively with topic intimacy ($r(136) = .22$, p = .009), and negatively with the preferred subjective length of a conversation ($r(136) = -.22$, p = .011). Accordingly, this correlation pattern suggests that individuals who experienced higher levels of pre-pandemic loneliness attributed fewer warmth-related characteristics to the robot, they reported wanting to talk less extensively with the robot, but likewise, named more intimate conversation topics for a human-robot conversation. Inspecting the subscales of the self-disclosure scale, neither the willingness to disclose positive nor negative topics high in intimacy were associated with any loneliness measure or the feeling of exclusion. The same holds true for preferred conversation intimacy, perceived experience, competence of the robot, and the number of named conversation topics.

Accordingly, our data suggest that participants' willingness to self-disclose highly intimate topics was independent from loneliness and the feeling of exclusion. The same was true for participants' desire for a personal conversation with the robot, for how much ability to feel and sense they attributed to the robot, how competent they assessed the robot to be, and how many conversation topics they spontaneously named. Further exploratory analyses are presented in the Supplementary Material, e.g., a MANOVA with inclusionary status as the independent variable and the perceived competence of the robot, topic intimacy, number of suggested conversation topics, positive anticipation of a conversation, and preferred length of a conversation as dependent variables.

Table 2. Correlations of current loneliness, pre-pandemic loneliness, situational loneliness, and feeling of exclusion with all dependent variables.

Variable	1	2	3	4
1. Current Loneliness	—			
2. Pre-pandemic Loneliness	.44 ***	—		
3. Situational Loneliness	.56 ***	−.50 ***	—	
4. Feeling of Exclusion	.21 *	.11	.10	—
5. Overall Willingness to Self-Disclose	.08	−.11	.18 *	.04
6. Self-Disclosure (positive, low intimacy)	.14	−.13	.25 **	.03
7. Self-Disclosure (positive, high intimacy)	.05	−.11	.15	.05
8. Self-Disclosure (negative, high intimacy)	.01	−.06	.06	.05
9. Preferred Conversation Intimacy	.02	.02	−.01	.10
10. Warmth	−.02	−.20 *	.16	−.05
11. Agency	.19 *	−.04	.22 **	−.01
12. Experience	.06	−.03	.09	−.02
13. Competence	.04	−.10	.13	.01
14. Topic Intimacy	.20 *	.22 *	−.01	.09
15. Number of Named Conversation Topics	.13	−.04	.16	.07
16. Anticipation	.17	−.13	.28 **	.10
17. Objective Length of Conversation (in minutes)	.16	−.01	.16	.20 *
18. Subjective Length of Conversation	.04	−.22 *	.23 **	.15

Note. *** $p < .001$, ** $p < .01$, * $p < .05$.

4. Discussion

In the present experiment, we investigated the effect of the inclusionary status on the willingness to self-disclose towards a humanoid robot, the preferred intimacy of a conversation, and on perceptions of warmth, experience, and agency. All main hypotheses were based on the assumption that individuals seek new social bonds and perceive robots more as social interaction partners when feeling socially excluded. Through this behaviour, socially excluded individuals would enable themselves to meet their need to belong. Looking at the main results, the present research replicated and extended previous work by investigating attributions of warmth and willingness to self-disclose towards a robot, above and beyond mind perception [34]. However, contrary to our predictions, inclusionary status did not influence the willingness to self-disclose, the preferred intimacy of a conversation, the perception of warmth, agency, and experience of a humanoid robot. Several explanations need to be taken into account for these unexpected results.

According to Hypothesis 1, participants should have been more willing to engage in self-disclosure and indicate a more intimate conversation in the exclusion condition compared to the inclusion and the control condition. Contrary to our prediction, results indicated that the feeling of exclusion did not affect the willingness to self-disclose or the preferred conversation intimacy of the imagined conversation. The online format of the

experiment might have weakened possible effects of exclusion on the willingness to self-disclose, given that prior research has pointed out that people do not try to connect with unknown others if a face-to-face interaction is unlikely to occur [11]. Furthermore, the experimental manipulation might not have been intense enough to elicit an effect on the willingness to self-disclose, as participants were merely instructed to recall an incident that involved social exclusion, while other social exclusion manipulations are based on the real experience of social exclusion, e.g., in the Cyberball paradigm [63]. Thus, a standard manipulation of inclusionary status would potentially evoke stronger effects. In addition, self-disclosure might require self-awareness, as you need to reflect on yourself to talk about yourself, which is supported by the result that private self-consciousness is positively associated with self-disclosure towards peers [64]. However, feelings of exclusion lead to a reduction in self-awareness as a self-protective strategy [10]. It is possible that we did not obtain any effect of exclusion on self-disclosure because of participants' reduced self-awareness. It is possible that people would try to connect with robots to fulfil their need to belong by other connection strategies than self-disclosure, because they want to avoid self-awareness but still want to connect. To illustrate, people might want to ask the robot questions to socially connect with it, but not answer questions about themselves. In the present experiment, we only offered self-disclosure as a connection strategy. Thus, future studies should offer social connection possibilities that do not require participants' self-disclosure, e.g., meeting the robot to ask questions or playing games with the robot. If the focus of the conversation would be the robot because humans might not want to talk about themselves, then it might be beneficial to use social robots equipped with sophisticated verbal communication capacities based on artificial intelligence and with the ability to detect human emotions for HRI. Ideally, such a robot would be able to perceive negative emotional states in a human that might have been elicited through social exclusion. As a consequence, such a robot might offer a conversation that does not involve self-disclosure on the part of the human. The robot Pepper (Aldebaran) represents an off-the-shelf robot platform able to detect emotions and it can be equipped with artificial intelligence. Thus, the robot Pepper and robots with similar abilities might be especially useful in future studies to investigate the effect of social exclusion on the willingness to self-disclose. Furthermore, future research should assess perceived self-awareness and the expectancy to meet the robot to investigate the underlying mechanisms that possibly explain the unexpected missing effect of social exclusion on the willingness to self-disclose.

According to Hypothesis 2, we predicted that the perception of warmth would be higher in the exclusion condition compared to the other conditions, but this hypothesis was not supported. We argued before that perceiving warmth in others is beneficial to form new social relationships [26] and thus would facilitate social connection. Hence, it seems that participants in the exclusion condition were not more keen to socially connect with the robot than participants in the other conditions. Again, the fact that a face-to-face interaction was not announced might have weakened the effect of social exclusion on approach behaviour [11] and possibly also on perceived warmth. According to Hypothesis 3 and 4, we expected higher attributions of agency and experience in the social exclusion condition compared to the other conditions. However, our data did not lend support for these hypotheses. Indeed, our findings clearly diverge from previous results by Eyssel and Reich, who found increased mind perception in a robot in participants recalling social exclusion [34]. All in all, the results of the present experiment indicate that the present research should be replicated including the anticipation of actual HRI. This was originally planned in the present research, but the COVID-19 pandemic did not allow for lab-based research studies. Consequently, we had to adapt the original research idea to the context of running the experiment online.

Nonetheless, the correlational results regarding situational loneliness provide support for the theoretical ideas that represent the basis of our research. For instance, we found that situational loneliness was associated with seeking social connection with a

humanoid robot. Indeed, the more participants reported situational loneliness, the more they were willing to self-disclose towards a humanoid robot regarding self-disclosure topics low in intimacy. Furthermore, the more participants indicated situational loneliness, the more agency they attributed to the robot, the more they looked forward towards a conversation, and the longer the desired subjective length of the conversation. These results are in line with prior research and support the idea that robots offer the potential to socially connect with them [34].

The pandemic situation that was present during data collection allows for the interpretation of pre-pandemic loneliness in terms of rather chronic loneliness, whereas current loneliness may be interpreted as a combination of chronic loneliness and situational loneliness. Chronically lonely individuals possess more personal vulnerabilities, e.g., a lack of social skills and a negative view of others [39]. These shortcomings make it harder for them to reconnect with others [65]. The correlation patterns regarding pre-pandemic loneliness provide weak support for the assumption that people who are chronically lonely tend to not reconnect or compensate with robots. In fact, people who reported more pre-pandemic loneliness attributed fewer warmth-related characteristics to the robot and wanted to have a subjectively shorter conversation with it. However, the more pre-pandemic loneliness participants reported, the higher the intimacy of the conversation topics they named. Possibly, lonely individuals named more negative conversation topics because such individuals often tend to report more negative cognitions [40] and face more negative experiences in their life, at least regarding their need to belong. Negative self-disclosure topics are usually perceived as more intimate and thus less appropriate to discuss with casual acquaintances [66], which would explain that more lonely individuals named more intimate conversation topics. In sum, it might be possible that in chronically lonely individuals the same cognitions, behaviours, and negative expectations that prevent them from connecting in human–human interactions also prevent them from connecting with social robots. However, this circumstance also points to a potential benefit of using robots, as they would naturally not react negatively when a conversation partner would suddenly cover rather negative, intimate topics in a conversation. Thereby, chronically lonely people could use social robots to talk about negative self-disclosure topics high in intimacy without fearing social rejection. Talking about negative experiences and problems could be a relief [67]. Using robots for this purpose could offer psychological benefits without risking human-human relationships because a human conversation partner might deem a negative topic high in intimacy as inappropriate.

To alleviate situational loneliness, social robots could be strategically placed in contexts in which such an emotional experience likely occurs, e.g., in universities to support incoming students who might have moved to a new city without knowing anyone [68]. In the context of a global pandemic, social robots have also proved useful [30], e.g., they can be deployed with people in quarantine, serve as a companion to risk-patients, or keep company of people who live alone to reduce the negative effects of situational loneliness. Our results indicate that situationally lonely people were more positively inclined towards a conversation with a social robot and were more willing to self-disclose about topics low in intimacy. Thus, social robots should have functions that entail verbal communication which enable mutual exchange, especially about self-disclosure topics low in intimacy. Nonetheless, some social robots do not even seem to need verbal communication capacities to reduce loneliness, and people can still talk to a robot, even though the robot does not respond verbally [28]. Thus, even robots without verbal capacities could be used for people at risk of loneliness.

Even though our findings contribute to the understanding of the role of feelings of exclusion and loneliness in the context of social reconnection with social robots in an important way, we have to address a number of methodological limitations in future research. First, the experiment was conducted online, therefore the conversation with the robot was only imagined. This has several implications. One implication is that only

intentions to self-disclose towards the social robot NAO were measured. This is potentially problematic, as people do not seek reconnection with unknown interaction partners with whom no face-to-face interaction is expected [11]. Thus, the online format and the imagined conversation possibly weakened the effect on the willingness to self-disclose. Future experiments should feature actual HRI, including a real self-disclosure scenario to enable greater external validity. The actual behaviour towards a social robot can only be investigated through real human-robot interaction that features opportunities for human-robot self-disclosure. Ideally, future work investigates these research questions using a socially intelligent robot with verbal communication capacities based on artificial intelligence. That way, the dynamics of human-robot self-disclosure could be investigated more optimally. Additionally, the online setting did not allow to control for confounding variables. We tried to rule out some confounding variables with questions (e.g., if participants really were alone and in a quiet place), but there still might have been confounding variables that we did not ask about or the participants did not indicate, e.g., if they were interrupted by a call or message during study participation. Therefore, future research should try to replicate the findings in a controlled laboratory setting where an experimenter can note any special occurrences.

Second, if no real interaction would be possible in future studies, video material in which the robot is introduced might facilitate a realistic impression of the robot and its capabilities. Being insecure about the true abilities of the robot and its interaction behaviour could lead to fewer valid attributions of robot characteristics. This limitation of the present experiment could also be remedied by running a laboratory experiment in which participants see the robot and actually interact with it.

Third, pre-pandemic loneliness was only measured as subjective post-hoc indication in the present research; thus, this loneliness measure might be biased through memory and not exactly reflect how participants felt before the COVID-19 pandemic. Even though the score correlated with several variables associated with social connection, a longitudinal design with at least two time points would improve the accuracy of the loneliness measure. To test the generalizability of the results, the experiment could also be replicated in other contexts (apart from a pandemic) in which the circumstances potentially promote feelings of loneliness, e.g., the transition from high school to university, relocation, and associated loss of social network [68], e.g., with Erasmus students.

To shed further light on the role of feelings of exclusion and situational loneliness, future studies could use an explicit situational loneliness recall task instead of a recall task emphasizing social exclusion. While social exclusion is usually a specific event, e.g., being the only one in a group of friends not invited to a party, situational loneliness is usually caused by a life event, e.g., moving to a new city. This might both result in an unfulfilled need to belong, but the quality and the duration of the feeling of lack of belongingness might differ. Thus, future studies should disentangle these two concepts and compare them directly. When future experiments want to manipulate social exclusion the use of immersive virtual reality might strengthen it. For instance, virtual reality has proven especially effective to elicit emotional responses [69], and thus might also increase feelings of social exclusion for a social exclusion manipulation. Furthermore, immersive virtual reality increases the ecological validity of social exclusion paradigms [70] and allows for the use of the Cyberball paradigm [71] as well as new social exclusion paradigms, e.g., being implicitly or explicitly excluded by a group of people in a virtual reality scenario [70]. In sum, we recommend an improved manipulation of the inclusionary status. It could also be useful to measure the willingness to communicate and interact with the robot in a less personal way than self-disclosure, as it is possible that socially excluded participants were motivated to socially connect with the social robot, but only in a less vulnerable way than through self-disclosure. It might also bring some fruitful insights to use human control groups to find out if the same results can be observed towards a human and a robot interaction partner. As a general remark, we believe that future research on robots

that might help individuals with an unfulfilled need to belong would benefit from an interdisciplinary perspective so that a realistic future use of such robots can be facilitated.

5. Conclusions

The present experiment offers important insights into how people react to feelings of exclusion and loneliness by turning to social connection strategies that include social robots. Although no effects of the inclusionary status on indicators for social connection were observed, the results indicate that people who feel situationally lonely due to circumstances such as the COVID-19 pandemic (vs. being chronically lonely) see social robots as a chance to socially connect and might accept them as social interaction partners. Likewise, our results indicate that chronically lonely individuals have a more negative view of social robots: They tend to reject a social robot as a conversation partner and attribute less warmth to a robot. Overall, our results support the idea that robots with communication skills could be used in contexts that are marked by situational loneliness, as individuals would be more willing to accept them as social interaction partners. By interacting with social robots, detrimental consequences associated with loneliness could be alleviated. Thus, social robots could do their share to improve well-being and health outcomes in contexts that render human-human contact unavailable to restore the essential human need to belong.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/robotics11060121/s1. In the Supplementary Materials, we report age (Table S1, age in the three conditions) and gender (Table S2, gender in the three conditions in absolute values) distribution across the inclusionary status conditions, as well as positive and negative affect, quality of the imagination of the conversation, estimated conversation incapability, robot experiences, technology commitment, current loneliness during the start of the COVID-19 pandemic, pre-pandemic loneliness, and social anxiety (Table S3, descriptive statistics of the exploratory variables considered as covariates within the three conditions). . Furthermore, we provide descriptive statistics and further analyses on the additional dependent variables, which are perceived competence, assessed topic intimacy of suggested topics for a conversation with the robot, number of named conversation topics for a conversation with the robot, positive anticipation of a conversation with the robot, preferred length of a conversation with the robot indicated in minutes, and preferred subjective length of a conversation with the robot (Table S4, descriptive statistics of the additional dependent variables within the three conditions). In addition, we report analyses on the self-disclosure subscales, which vary in valence and intimacy (Table S5, descriptive statistics of the self-disclosure subscales within the three conditions).

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