



Contagious humans: A pandemic's positive effect on attitudes towards care robots

Manuela Schönmann^{b,d}, Anja Bodenschatz^{a,b,c,*}, Matthias Uhl^{a,b}, Gari Walkowitz^{b,d}

^a Faculty of Computer Science, Technische Hochschule Ingolstadt, Esplanade 10, 85049, Ingolstadt, Germany

^b TUM School of Social Sciences and Technology, Technical University of Munich, Arcisstraße 21, 80333, Munich, Germany

^c Seminar for Corporate Development and Business Ethics, Faculty of Management, Economics and Social Sciences, University of Cologne, Albertus-Magnus-Platz, 50923, Cologne, Germany

^d Faculty of Business Administration, Technische Universität Bergakademie Freiberg, Freiberg, Germany

ARTICLE INFO

Keywords:

Care robots
Affective attitudes
COVID-19 pandemic
Vignette experiment

ABSTRACT

History has shown that attitudes toward new technologies can change abruptly following disruptive events. During the COVID-19 pandemic, it became apparent that care robots enable increased social isolation. This feature of robotic care usually raises strong ethical concerns about potentially decreased comfort for the care-dependent. In a large-scale online study, we tested the influence of the pandemic on people's affective attitudes toward care robots. In vignettes on different care scenarios, we measured participants' perceived comfort levels in situations with care robots and human caregivers while controlling for their fear of infection with a viral disease. We found that people generally feel less comfortable with a care robot than with a human caregiver. However, those who had a strong fear of being infected during the pandemic did not devalue a care robot compared to a human caregiver. While care robots remain ethically contested, this study shows that affective attitudes toward care robots may change significantly if they can address an urgent need.

1. Introduction

People's attitudes toward technology are not stable over time. This is true for societies as a whole, whose attitudes toward the same technology may evolve dramatically over the course of only a few generations. Even the very same people can be subject to attitudinal change over their lifetime. As people get immersed in technologies, they may adapt to them and slowly build trust. Sometimes, changes in attitudes toward technology may even be induced disruptively. Trust may suddenly erode when a catastrophe shifts people's focus from the opportunities of a technology to its threats. The Fukushima nuclear disaster of 2011, for instance, had a profoundly negative immediate influence on public opinion on nuclear power [1–3]. Other prominent examples include a change in flight anxiety in the aftermath of the terrorist attack of September 11 [4,5] or a shift in public attitude toward the promising technology of autonomous vehicles after reported accidents [6]. As is typical of trust in general, of which one says that it takes years to build but seconds to break, cases in which trust in a technology would quickly build up seem less frequent. However, instances are also conceivable

that may lead to a stronger adaption of technologies due to external disruptive events. Early evidence suggests that the war between Russia and Ukraine raised public support for clean energy policies in Switzerland [7]. Studies conducted after 9/11 suggested that fear of crime and terrorism drive acceptance of governmental security and surveillance measures via technology [8]. In this paper, we will consider the question of whether the social disruptions caused by the COVID-19 pandemic that broke out in 2019 could lead to an increasing acceptance of the technology of care robots. This conjecture is based on re-evaluations of interpersonal closeness during the pandemic, as exemplified by the replacement of the handshake by the cleaner fist bump [9]. Care robots face the concern that their usage would lead to a dehumanization of care caused by decreasing contact between care personnel and care-dependents. At a time, however, in which human contact was associated with a threat of infection, a robotization of care could suddenly be viewed more positively [10]. While many might have associated the "sterility" of a care robot with its soullessness before the pandemic, it might have been interpreted more often in its literal clinical sense during the pandemic.

* Corresponding author. Technische Hochschule Ingolstadt, Esplanade 10, 85049, Ingolstadt, Germany.

E-mail addresses: manuela.schoenmann@bwl.tu-freiberg.de (M. Schönmann), anja.bodenschatz@thi.de (A. Bodenschatz), matthias.uhl@thi.de (M. Uhl), gari.walkowitz@bwl.tu-freiberg.de (G. Walkowitz).

<https://doi.org/10.1016/j.techsoc.2024.102464>

Received 11 August 2023; Received in revised form 8 November 2023; Accepted 10 January 2024

Available online 11 January 2024

0160-791X/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

This paper proceeds as follows. In the second section, we will elaborate on the theoretical background of our research. We will discuss the relevance of social robotics for modern life in general and nursing, as well as geriatric care in particular, and review some of the works on attitudes toward robots and how these could be subject to change. This will be complemented by thoughts on how the COVID-19 pandemic could have fostered such attitudinal change. In the third section, we will explain the research method we employed to analyze the correlation between the fear of getting infected by the virus and the attitude toward robots in nursing and geriatric care. The fourth section outlines the results of this analysis, while the fifth section will discuss these implications.

2. Theoretical background

2.1. The ubiquity of robots in modern life

Controversial assessments and negative attitudes toward new technologies are not new to the 21st century but can be found in a variety of innovations throughout human history, especially since the beginning of the Industrial Revolution [11]. The chain of modern technology controversies can be traced to the early 19th century with the machine breakers who, fearing job loss and social decline, violently protested the advent of spinning, weaving, and steam engines. This chain continues through warnings about the unforeseeable and unpredictable consequences of the “beast” railway to outright hostility toward automobilization and, since the second half of the 20th century, to opposition to nuclear power and genetic engineering [11]. The current debate over whether artificial intelligence (AI) will destroy or enhance humanity can be seen as the latest, but most likely not the last, link in this chain of modernization controversies. In the form of ever more “autonomously” acting robots, recent developments in the broad areas of AI, sensor technology, mechatronics, and electronics and the accompanying changes in the human social environment are becoming increasingly visible and ubiquitous. More and more, these robots are no longer hidden behind factory walls or in areas inaccessible to the public (such as space travel or nuclear power plants) but come closer to people in their everyday lives [12]: Vacuum cleaners and lawn mowers take care of home and garden maintenance seemingly without human intervention, friendly robotic assistants answer questions in shopping malls, small humanoids entertain and animate senior citizens in nursing homes, artificial seals assist in the therapy of dementia patients, and robotic teachers help with vocabulary learning and math problems. These new application areas require robots to increasingly interact, cooperate, and communicate with humans, becoming more “social” [13]. One area of life that has so far been considered genuinely human, but for which increased use of “autonomous” and “social” technology may become indispensable in the coming years, is the care for vulnerable persons such as older adults.

2.2. Social robots in care

In almost all countries of the world, the proportion of people over 60 years of age has been increasing for several decades and with it the demand for support from long-term care services, including nursing homes and long-term care facilities [14]. Older age usually leads to increasing health needs, multimorbidity, and therefore, sooner or later, often to the need for nursing care [15]. Yet many regions already face a shortage of health workers to care for older adults, as well as for sick and disabled people [16]. Closing the growing gap between the demand and supply of professional caregivers is an increasing challenge, especially for countries with a high “old-age dependency ratio” (i.e., a high number of people over 65 per person aged 20 to 64) [17]. One possible measure could be using assistive technologies to supplement human caregiving. These so-called care robots can be defined broadly as “robots intended to assist or replace human caregivers in the practice of caring for vulnerable persons such as the elderly, young, sick, or disabled” [[18], p. 251].

However, while technologies that relieve humans of heavy physical labor on production lines, for example, are widely accepted by now, the question of whether we should welcome or reject robots in a social, human environment is controversial.

On the one hand, *human* caring, *human* presence, and *human* touch are seen as the core of nursing activities [19]. Thus, robots, by their very nature, cannot provide “genuine” care but only “mechanized” care [19, 20]. Consequently, the use of robots would remove the “human element” from care [21], which is in danger of being reduced to purpose-driven concerns under economic efficiency pressure [12]. The use of care robots could, therefore, socially isolate care recipients, limit their self-determination, threaten their self-efficacy, deprive them of social recognition, and violate their dignity [22–26]. On the other hand, shifting routine tasks to robots could allow human caregivers to focus more on emotional and interpersonal aspects, i.e., the genuinely human part of caregiving [27]. Care robots that assist the care-dependent with basic activities of daily living, such as bathing or toileting, could also help them become more independent of other people and improve their autonomy [28,29]. This, in turn, could have a positive impact on the sense of dignity and well-being of people in need of care [29,30]. Ultimately, on the side of concerns about care robots, the discussion is mostly conducted on a normative level, and the ideal of the human caregiver is not questioned. However, to the best of our knowledge, the thesis that care provided by robots is also perceived as *worse care* from the perspective of the people being cared for has hardly been challenged [31].

2.3. Attitudes toward robots

It becomes clear that views and attitudes toward robots, especially social robots, are currently anything but homogeneous or settled. The need to cooperate underpins human social structures and has evolved over millennia [32,33]. In contrast, the need to communicate and collaborate with robots is a very recent phenomenon [34,35]. Unlike in human interaction, social norms and behaviors in human-robot interaction have not yet been established, and neither have human attitudes toward robots.

Attitudes encapsulate all kinds of thoughts, beliefs, feelings, emotions, and behavior related to virtually anything someone may have in mind, be it other people, concrete things, or abstract ideas [36,37]. These, sometimes unconscious, evaluations toward so-called *attitude objects* play an essential role in how people perceive and simplify their environment [38,39] and are made on a cognitive, affective, or behavioral basis [37,40]. Cognitive attitudes comprise a person’s beliefs and thoughts about an attitude object, whereas emotional reactions and feelings about that object constitute affective attitudes. Observable actions and behavioral intentions, in turn, are the content of behavioral attitudes [41]. Taken together, the individual evaluations form an overall attitude toward an attitude object. However, the three components are not necessarily equally strong and may well conflict with each other [42]. Take the example of social robots: a person might find robots generally useful and, therefore, have a positive cognitive attitude [43]. At the same time, however, she might feel uncomfortable at the idea of interacting with a robot, which represents a negative affective attitude [43]. Now, suppose this person encounters a service robot in a shopping mall, for example. In that case, she might approach it and ask it for help or actively interfere with it, or she might simply avoid the robot, expressing different behavioral attitudes.

Whether someone reacts positively or negatively to an attitude object, e.g., a robot, in a concrete situation depends on previous experiences with and evaluations of this entity already stored in memory. However, when confronted with something unfamiliar (such as a novel technology), a person can also form attitudes “on the spot” to be able to react to the unfamiliar [44]. Without prior experiences and evaluations, these instant attitudes are based primarily on affective feelings toward contextual associations [44,45], for instance, toward existing, known

technologies [46]. With repeated exposure, attitudes may increasingly be based on cognitive inferences such as factual information, resulting in more crystallized, stable, and often more positive attitudes [44,47,48]. Being confronted with robots in real life will likely be a new experience for most people. Therefore, their attitudes toward robots might still be much more influenced by individual experiences, the social environment, the context of interaction and specific characteristics of a robot, and may be more likely to change [36,43]. Previous empirical research in various social science fields supports this notion by showing different results in attitudes toward social robots (including care robots) in terms of acceptance, fear, affective, cognitive, and behavioral attitudes depending on the population studied, the context of use, and prior contact with robots [49,50]. Some studies suggest that people have mildly positive attitudes toward social robots [24,50–53] and would not be averse to interacting with them [43] or would even prefer robot assistance in daily life over human caregivers [54]. Others have reported more mixed reactions [20,55] or calls to ban robots from social settings like geriatric care [56–59]. Much of the current literature has also examined potential applications and tasks for social and care robots, along with how particular design features and attributes may impact people's acceptance of specific care robots [24,49,51,59–63].

2.4. Changes in attitudes and values

The evaluation of the different attitude dimensions is not dichotomous but takes place along different continua, such as favorable to unfavorable, supportive to hostile, pleasant to unpleasant, good to bad, or harmful to useful [38,43,64]. Consistent with this, attitude change describes a shift along these continua such that the evaluation category changes, e.g., from favorable to unfavorable [65]. Attitude changes often do not follow overt persuasion or conscious influence but are implicitly induced [65]. Value-expression counts as one primary function of attitudes [37]. That is, attitudes serve as a means to communicate an individual's "core conceptions of the desirable" [66]. Accordingly, values have been found to be potential determinants of attitudes, e.g., toward the unemployed [37], toward out-group prejudice [67], but also of attitudes toward various technologies, such as nuclear energy [37], smart-grid technology [68], technology in the hotel sector [69], and telecare robots [70]. Although values tend to be stable, they are by no means rigid but change, and with them, in some circumstances, associated attitudes [66]. Gradual changes can be observed over the various stages of a person's life, so that, for example, the importance of values such as "caring for others" may increase when a person becomes a parent [71]. In addition to these rather evolutionary changes, individual values and attitudes also respond to disruptive external influences, such as non-normative critical life events [65,71]. On the one hand, this influence can directly induce attitude change, e.g., in the form of increased pro-environmental political and social attitudes following extreme weather events such as a hurricane [72] or more conservative political attitudes in the wake of the 2007-08 global financial crisis [73].

Second, changes in attitudes are also likely to be driven by changes in higher-level values through the relationship between values and attitudes described earlier. Substantial changes in a person's value structure have been found, for instance, following a diagnosis with a life-threatening illness [74] or following transitions that affect multiple domains of life, such as migration [75]. Similarly, it has been observed that collective, critical life events can lead to value changes at the societal level. For example, after terrorist attacks [76], during war [77], and economic and financial crises [78], a population-wide increase in values of self-protection, so-called conservation values, such as security and conformity [79], has been observed. Values and related attitudes thus appear to be particularly sensitive to fear, anxiety, and actual or perceived threats to individual well-being [65,80].

The changes described here are not only reflected in people's personal values or political and social attitudes but may also be reflected in their attitudes toward certain technologies. For example, several studies

examined public attitudes toward nuclear energy in worldwide after accidents at nuclear power plants. The results show that after the accidents, confidence in and support for the use of nuclear energy decreased, while negative attitudes increased [81,82]. Interestingly, studies after the Fukushima accident 2011 also found a significant increase in pro-environmental beliefs [83] and more positive general attitudes toward renewable energy [84]. Thus, although the accident was not associated with renewable energy, it nonetheless influenced perceptions and evaluations of these technologies [84]. Not accounting for such broader changes in values and the resulting changes in attitudes when governing a novel technology could well mean imposing yesterday's regulations on tomorrow's society.

2.5. The COVID-19 pandemic as disruptor of attitudes toward social robots

More recently, the COVID-19 pandemic posed a potential threat to individual well-being and triggered numerous forms of anxiety and fear among people worldwide [85,86]. Almost all regions have enacted physical distancing and "stay-at-home" orders to contain the spread of the virus [87]. The associated lockdowns have fundamentally changed the way people work, access services, spend their leisure time, and communicate and interact with others, thus disrupting the lives of many people around the world. Digital interaction has become a necessity in many areas of life, which has also been reflected in changing attitudes toward various technologies, such as the use of digital technology by older adults [88], public policymakers' confidence in the ability of information and communication technology to help their cities achieve different goals and overcome challenges [89], and attitudes of students toward digital learning technologies [90]. Furthermore, consistent with the literature on value change, significant and complex value changes have been observed in different countries. For instance, conservation values increased in importance, while openness to change values decreased [91,92]. In addition, the importance of values of self-transcendence, which refer to concern for the well-being of others, decreased significantly toward the end of 2020, the first year of the pandemic. At the beginning of the pandemic, concern for distant others decreased significantly, a persistent effect that later extended to concern for close others. Daniel et al. [92] explain this as an increased withdrawal by some individuals due to constant worry. Humankind, however, is a social species. Penner and Eyssele [93] showed that people who experienced more COVID-19-induced loneliness were more willing to accept social robots as social interaction partners. Other technological applications also gained from the pandemic. The negative feelings induced by the global crisis inspired positive attitudes toward surveillance technologies, such as tracking applications for disease control [94]. However, some of these initial value shifts revised after a few months of the pandemic, so it is assumed that people's value systems are flexible, strongly responsive to external circumstances, and appear to adapt to complex new life situations during an ongoing crisis [91,92]. The disruption caused by a global health threat has most likely caused "a rapid reorganization of what people consider important in life" [90, p.10], and long-term implications are expected [92]. One of these long-term implications could be how we view and value fellow human beings and human proximity. A novel viral disease has turned what we value in others, such as personal visitation, intimacy, and human closeness, into a potential threat to health and well-being. This is likely to be particularly pronounced in nursing and geriatric care, an area of life that was previously considered genuinely human but which was and is particularly affected by the pandemic. In turn, the sterility and precisely non-humanity of robots could now be seen as a positive characteristic representing safe care. Therefore, it is conceivable that attitudes toward care robots correlate with fears induced by the COVID-19 pandemic. Specifically, we hypothesize that the greater the fear of viral infection by other fellow humans, the more positively robots are viewed.

To test this hypothesis, we examined participants' affective attitudes toward care robots in an experimental vignette study. Following [18], we consider care robots to be a general category of robots that replace human caregivers in daily care activities for individuals in need of care. We further do not limit our definition to a particular appearance or type of robot. We aimed to elicit an emotional, non-rationalized response in participants to different caregivers, human or artificial, by asking them how comfortable they would feel in different care scenarios. Emotional responses and feelings toward things, ideas, or other people are referred to as "affective attitudes" (as opposed to, for example, cognitive attitudes, which encompass a person's thoughts and beliefs) [36,41]. Attitudes and feelings such as anxiety have a significant impact on older people's intention to use assistive robotics technology [95]. Affective attitudes are therefore also an important factor in the acceptance of potential care technologies.

3. Methods

3.1. Study and vignette design

To test our hypothesis, we built on a large-scale survey in which we examined how people's affective attitudes (i.e., their feelings or emotions) toward care robots compare to their affective attitudes toward human caregivers in different care situations in nursing homes depending on personal experience with being in need of care [31]. The main characteristics relevant to our study are outlined below.

The study used a text vignette methodology and a 2 (*human vs. robot caregiver*) × 2 (*intimate vs. non-intimate scenario*) mixed design that included one between-subjects manipulation and one within-subjects manipulation. We designed the nature of the caregiver as between-subjects manipulation and the intimacy of the scenario as within-subjects manipulation. Accordingly, each participant read two vignettes about two care scenarios, an *intimate* and a *non-intimate* one, but both described either a *human* or a *robot* as the caregiver. Vignettes have long been used in the social sciences and nursing research [96], and are considered a valuable method for examining people's perceptions, beliefs, and opinions about specific situations, especially sensitive topics, or for comparing views of different groups [97]. At the beginning of the experiment, participants were asked to put themselves in the situation of unexpectedly needing care and having to move to a long-term care facility where human caregivers and care robots share the work. Participants were then randomly assigned to one of two between-subjects experimental conditions. Accordingly, about half of the participants were informed that they would live in a ward with a human caregiver, while the other half read that a care robot was responsible for their ward. In addition, to bring the nature of the caregiver into focus for participants, we emphasized that their attitude toward "their" caregiver was of particular interest to us. All participants were then presented with two vignettes in which we varied the intimacy of the care situation as within-subjects manipulation. Both vignettes included two entities: a caregiver and a care recipient (the participant). One vignette described an intimate care scenario in which the caregiver helps the care recipient with personal hygiene (*intimate scenario*). The other vignette dealt with a non-intimate care scenario in which the care recipient receives a glass of water and is nudged by the caregiver to drink something (*non-intimate scenario*). The scenarios were shown in a random order to balance the study and address potential order effects. We focused on participants' affective reactions to the two different caregivers in general rather than on their perceptions of specific characteristics as positive or negative. Therefore, the vignettes described the scenarios *ceteris paribus* and did not include information or illustrations about the particular appearance or characteristics of the human caregiver and the care robot.

3.2. Measures

In the following, we will explain the measures from the vignette

experiment that are of interest to the study at hand.

3.2.1. Perceived level of comfort

To assess participants' affective attitude toward a particular caregiver, human or robot, we asked them to self-assess their perceived level of comfort in the described care situations. For each of the two vignettes, participants rated the statement "I feel comfortable in the described situation" on a 7-point Likert scale ranging from 0 (*completely disagree*) to 6 (*completely agree*).

3.2.2. Concern about contagion

To evaluate the potential influence of people's concern about infection with a viral disease by other humans on their attitude toward different caregivers, we asked participants to rate the statement "I am concerned about getting infected with a viral disease (e.g., influenza, COVID-19) by the human caregivers from my care facility." The rating was done on the same 7-point Likert scale as the rating of participants' perceived level of comfort (0 = *completely disagree* to 6 = *completely agree*).

3.2.3. Demographic factors

Age and gender have been found to influence people's general attitudes toward robots, such that men have more positive attitudes toward robots than women, as do younger people compared to older adults [57, 98]. However, some studies suggest that older people evaluate care robots more positively than, for example, caregivers do [50]. For these reasons, we asked participants about their age and gender.

3.2.4. Attitudes toward robots

General attitudes toward robots could also influence attitudes toward care robots. To control for this possible influence, we included an English version of the Negative Attitudes toward Robots Scale (NARS) by Nomura et al. [99] in the post-experimental questionnaire. The NARS is the most widely used psychometrically validated self-report inventory for assessing social acceptance of robots [100] and consists of three subscales with a total of 14 items. The subscales *Negative Attitudes toward Situations of Interaction with Robots* and *Negative Attitudes toward Emotions in Interactions with Robot* target affective attitudes (hereafter referred to as *NARS.Interaction* and *NARS.Emotions*, respectively) [43]. The *Negative Attitudes toward the Social Influence of Robots* subscale captures cognitive attitudes (*NARS.Influence*) [43]. Each item is rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Three items on the scale are positively worded; these are reverse coded so that for all items, higher scores reflect more negative attitudes.

3.3. Participants and procedure

The experiment was conducted online in June 2020 using the web application SoSci Survey to create the questionnaire [101] and the research platform Cloud Research to recruit participants [102]. Participants were randomly assigned to one of the two experimental conditions, *human* or *robot*. Multiple participation was excluded by CloudResearch. Participants were presented with two vignettes on care situations and rated their perceived level of comfort for each situation. After the experimental task, participants were asked to complete the NARS questionnaire and answer the two demographic questions on age and gender, as described in 3.2.

Out of 1413 individuals who started the questionnaire, 140 (9.9 %) failed to complete it. The remaining 1273 participants were included in our analysis (see Table 1 for demographic characteristics). Their ages ranged from 18 to 92 years ($M = 47.3$, $SD = 18.3$). As only very few participants reported their gender as non-binary, we limited our analysis to the binary gender categories. In total, 631 participants read the vignettes involving a *human caregiver*, and 642 read the ones involving a *care robot*.

Table 1
Demographic characteristics.

Baseline characteristic	Human Condition		Robot Condition		Full sample	
	n	%	n	%	n	%
Gender						
Female	381	60.4	378	58.9	759	59.6
Male	243	38.5	260	40.5	503	39.5
Age	<i>M (SD)</i>		<i>M (SD)</i>		<i>M (SD)</i>	
	47.1 (18.5)		47.4 (18.0)		47.3 (18.3)	

Note. *N* = 1273. No statistically significant differences were found between conditions in age ($p = .76$, unpaired *t*-test, two-sided) and gender ($p = .55$, χ^2 test). Nine participants did not report their age, and 11 did either report no or a non-binary gender.

Table 2
Concern about contagion and comfort depending on experimental condition and scenario.

	Human			Robot			Non-parametric test results	
	n	<i>M</i>	<i>SD</i>	n	<i>M</i>	<i>SD</i>	<i>p</i> -value	<i>d</i>
Concern about contagion	631	4.20	1.48	642	4.10	1.63	.53	0.06
Comfort with caregiver	631	4.40	1.24	642	3.71	1.72	<.001	0.46
Comfort depending on Caregiver × Scenario								
Intimate Scenario	631	3.94	1.25	642	3.67	1.06	<.001	0.31
Non-Intimate Scenario	631	4.86	1.25	642	4.05	1.06	<.001	0.51

Note. As non-parametric tests, Wilcoxon rank sum tests were used for the analyses on concern about contagion and comfort depending on the caregiver, and the Wilcoxon signed-rank test for the analyses including the within-subject manipulation of the scenario.

3.4. Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. The survey lasted approximately 20 min, and participation was compensated with a fixed amount of \$1.75. Informed

consent was obtained from participants via the survey platform, and they could discontinue the study at any time. There were no mandatory questions in the survey, so participants could skip questions they did not want to answer. The experiment data were stored only locally on the researchers’ computers.

4. Results

On average, participants reported feeling comfortable in the care situations ($M = 4.05$, $SD = 1.54$) and slightly concerned about being infected with a viral disease by human caregivers ($M = 4.15$, $SD = 1.56$). Whether participants were assigned to the human or robot experimental condition did not significantly affect their concern about contagion (see Table 2). The main results on participants’ concern about contagion and comfort can be inferred from Table 2.

4.1. Nature of the caregiver and intimacy of the scenario

In the first step of our analysis, we evaluated the influence of the nature of the caregiver (*human vs. robot*) and the interactive influence of the caregiver and scenario on perceived comfort.

Participants’ comfort levels were significantly lower in the robot conditions than in the human conditions, both independently and after accounting for the intimacy of the scenario (see Table 2). This supports the notion that people would prefer being cared for by humans rather than by robots. Surprisingly, the differences between reported comfort levels with human and robot caregivers were smaller in the intimate scenario ($\Delta = 0.57$) than in the non-intimate scenario ($\Delta = 0.80$). Thus, robot aversion was more pronounced in the non-intimate scenario than in the intimate scenario.

4.2. Concern about contagion

As shown in Table 2, participants in both the human and robot conditions were concerned about contracting a viral disease from a human caregiver. In the second step of our analysis, we thus examined the extent to which concern about contagion affects perceived comfort with human and robot caregivers in each of the two scenarios.

As shown in Fig. 1, concern about contracting a viral disease influences participants’ attitudes toward care robots in a way that

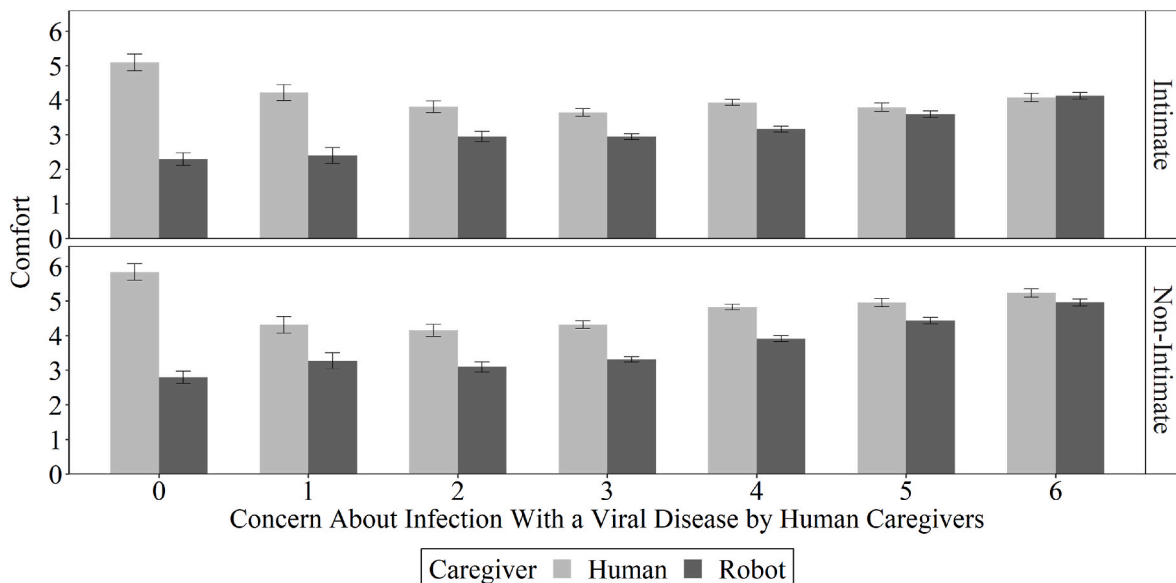


Fig. 1. Influence of concern about contagion by human caregivers on perceived comfort.

Table 3
Influence of caregiver, concern about contagion, and control variables on comfort.

Independent variable	Dependent variable: Comfort							
	Intimate scenario				Non-intimate scenario			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robot	-.571*** (.103)	-2.027*** (.304)	-1.970*** (.301)	-1.932*** (.323)	-.803*** (.087)	-1.933*** (.288)	-1.941*** (.288)	-1.702*** (.305)
Concern		-.039 (.050)	-.030 (.050)	-.035 (.050)		.124*** (.038)	.121*** (.038)	.114*** (.038)
Robot × concern		.354*** (.071)	.337*** (.070)	.341*** (.069)		.278*** (.062)	.278*** (.063)	.283*** (.062)
Age			-.177*** (.050)	.004 (.066)			.026 (.041)	.134*** (.049)
Female			-.527*** (.102)	-.480*** (.141)			-.090 (.085)	.134 (.107)
Robot × age				-.368*** (.099)				-.218*** (.081)
Robot × female				-.085 (.204)				-.434** (.169)
Constant	3.937*** (.069)	4.100*** (.210)	4.382*** (.221)	4.377*** (.224)	4.856*** (.051)	4.336*** (.177)	4.406*** (.184)	4.299*** (.186)
Observations	1273	1273	1256	1256	1273	1273	1256	1256
Adjusted R ²	.023	.060	.090	.098	.061	.149	.148	.156

Note: ***p* < .05; ****p* < .01.

Robust standard errors, clustered at the individual subject level, are shown in parentheses. In all models, the dependent variable is the degree of comfort, participants stated to feel in the described situation. Each participant evaluated two care scenarios: An intimate scenario (help with personal hygiene) and a non-intimate scenario (getting something to drink). The metric variable *age* was standardized before performing the regression analysis.

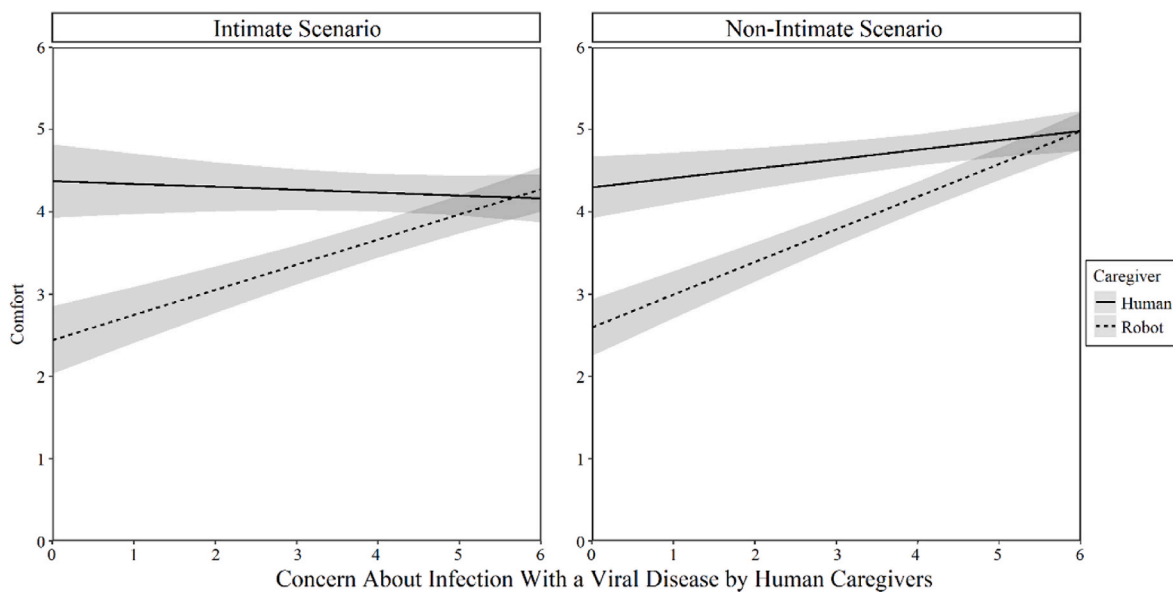


Fig. 2. Interactive influence of caregiver and concern about contagion on perceived comfort.

increases perceived comfort with robots. In both scenarios, the higher the concern about an infection by another human, the higher the perceived comfort with a care robot. Although comfort levels with human caregivers do not decrease to the same extent, the difference between the evaluation of the human caregiver and the care robot becomes smaller, i.e., the devaluation of robots compared to humans decreases with increasing concern about contagion.

To evaluate the influence of concern about contagion on affective attitudes toward care robots and to assess the robustness of our results, we next conducted a series of regression analyses, including concern about contagion and the demographic factors of age, gender, and participants' attitudes toward robots as covariates. The two dichotomous variables *caregiver* and *gender* were dummy coded so that the categories *human* and *male* were assigned the value 0 and *robot* and *female* were

assigned the value 1.

First, we replicated our results from the non-parametric analysis regarding the main effect of the caregiver on comfort. Consistent with our previous results, the nature of the caregiver (*Robot*, see Model 1 and Model 5 in Table 3) was a significant predictor of comfort in both scenarios. The negative regression coefficients indicate that in both scenarios, perceived comfort was lower with a care robot than with a human caregiver.

Furthermore, the regression analysis showed a significant positive interaction effect between the caregiver and concern about contagion (*Robot × concern* in Model 2 and Model 6, Table 3). This suggests that concern about contagion significantly increased participants' perceived comfort with care robots. The higher regression coefficients of the interaction of caregiver and concern about contagion (*Robot × concern*)

Table 4
Influence of concern about contagion from human caregivers on comfort with care robots.

Independent variable	Dependent variable: Comfort			
	Intimate scenario		Non-intimate scenario	
	(1)	(2)	(3)	(4)
Concern	.305*** (.048)	.169*** (.039)	.397*** (.049)	.299*** (.040)
Age	-.359*** (.073)	-.252*** (.063)	-.083 (.064)	-.020 (.058)
Female	-.564*** (.147)	-.144 (.132)	-.300** (.131)	.008 (.119)
NARS.Interaction		-.279** (.110)		-.279*** (.100)
NARS.Influence		-.054 (.112)		-.105 (.105)
NARS.Emotions		-.953*** (.077)		-.688*** (.076)
Constant	2.441*** (.233)	2.756*** (.172)	2.596*** (.241)	2.820*** (.187)
Observations	635	635	635	635
Adjusted R ²	.124	.389	.136	.336

Note: ***p* < .05; ****p* < .01.

Robust standard errors, clustered at the individual subject level, are shown in parentheses. Metric variables *age*, *NARS.Interaction*, *NARS.Emotions* and *NARS.Influence* were standardized before performing the regression analysis.

in the intimate scenario indicate that this influence is even more pronounced in an intimate situation.

As can be inferred from Fig. 2, perceived comfort was higher on average with a human caregiver than with a care robot, regardless of the participants' expressed concern about contagion. However, concern about infection from other humans appears to significantly decrease people's aversion toward care robots, to the point where perceived comfort is equal with a human caregiver and a care robot.

4.3. Influence of age and gender

We further included participants' age and gender and the interaction of the caregiver with both demographic factors as covariates in our regression models (see Table 3). The results show, first, that the influence of concern about contagion on perceived comfort is robust when controlling for sociodemographic factors, and second, that age and gender affect perceived comfort differently across scenarios and caregivers. For instance, female participants reported a lower comfort level than male participants in the intimate care scenario, regardless of the caregiver (*Female* and *Robot × female* in Model 4, Table 3). In the non-intimate care scenario, gender only influenced perceived comfort with care robots (*Robot × female* in Model 8, Table 3). In addition, the idea of being cared for by a robot negatively influenced older participants' comfort levels in both scenarios (*Robot × age* in Model 4 and Model 8, Table 3).

4.4. Influence of attitudes toward robots

Finally, we evaluated the robustness of our findings for the care robot conditions by controlling for participants' general robot aversion. We first performed a reliability analysis of the three subscales of the

Negative Attitudes toward Robots Scale based on participants' responses using Cronbach's Alpha. We removed one item from each of the NARS. Interaction and NARS.Influence scales due to low item-total-correlation.¹ As the number of missing answers was very low, these were imputed with the corresponding item mean.² The revised scales showed good internal consistency with Cronbach's Alphas of $\alpha = 0.85$ for NARS. Interaction, $\alpha = 0.76$ for NARS.Influence and $\alpha = 0.80$ for NARS.Emotions. The subscale scores were then calculated as sums of the corresponding items (see Nomura et al. [86]).

Controlling for individuals' attitudes toward robots mitigated the influence of concern about being infected with a viral disease on perceived comfort but did not fully mediate it. Higher concern about contagion continued to significantly increase perceived comfort with care robots in both scenarios (see Table 4, *Concern* in Models 2 and 4). This was different for the influence of sociodemographic factors: Controlling for NARS fully mediated the effect of gender on perceived comfort in both scenarios. The influence of age was fully mediated in the non-intimate scenario and partially mediated in the intimate scenario (see Table 4, *Age* and *Female* in Models 2 and 4). In addition, the results show differences in the influence of the three NARS subscales on perceived comfort. While strongly negative attitudes toward situations of interaction with robots or toward emotions in interaction with robots significantly decreased comfort ratings of participants with a care robot in both scenarios (see Table 4, *NARS.Interaction* and *NARS.Emotions* in Models 2 and 4), negative attitudes toward the social influence of robots had no significant effect (see Table 4, *NARS.Influence* in Models 2 and 4).

5. Discussion

In current public discourse, the development of robots that can perform caregiving tasks is often rejected as inhumane and inappropriate. Robots' lacking ability to perform "genuine care" seems more pronounced in the debate than possible positive aspects, such as for example, opportunities for an improved feeling of autonomy for the care-dependent. The COVID-19 pandemic, with its need for social distancing, suddenly turned a traditionally negatively connotated feature of robots into a positively connotated one: their sterility.

In this paper, we provided insights into how people perceive the use of care robots, considering their concern about infection with viral diseases. We found support for the notion that people would generally prefer human caregivers to care robots. However, the difference between perceived comfort levels in situations with human caregivers or care robots became smaller when people had stronger concerns about viral disease infection from human caregivers. While affective attitudes toward human caregivers did not become significantly more negative as concerns about contagion increased, affective attitudes toward care robots became significantly more positive. For study participants who displayed an elevated fear of contagion during an ongoing pandemic, a gap in the comfort level between a human caregiver and a care robot was nonexistent. One explanation for this is that in times where waves of infection run through society, human closeness, which is often considered as essential in caregiving [19], could endanger the health of vulnerable individuals. In contrast, the often negatively associated sterility and explicit non-humanity of robots could be positively perceived as protecting care recipients' safety. The fact that this effect was even more pronounced in the

¹ The deleted items were 7: "The word 'robot' means nothing to me" and 14: "I feel that in the future, society will be dominated by robots". The issues with these items are consistent with the findings of other studies that have used NARS in Western societies [113–115]. They suggest that item 7 may be outdated, while for item 14, perceptions of the possible future role of robots in society may be culturally biased due to differences in the prevalence of robots in different countries [114].

² The data of one participant who did not respond to any of the NARS items was removed from the data set for this part of the analysis.

intimate care scenario, i.e., a situation with close physical contact, supports this assumption. Our results also align with Aymerich-Franch and Ferrer [103], who found that crisis management was strongly related to social robot adaptation during the pandemic. The influence of participants' sociodemographic factors in our study, like age and gender, played a limited role in the robot aversion of participants as their influence was largely mitigated when controlling for participants' general attitude toward robots. None of the control variables fully mediated our main effect of a significant positive impact of the fear of contagion from a human caregiver on the comfort level in a scenario with a care robot.

This study concentrated on assessing people's affective attitudes. Nevertheless, the above findings are also in line with previous literature on cognitive attitudes. According to Ajzen [38] and his theory of planned behavior, a shift toward stronger support for care robots should occur for people with a fear of contagion because expected personal benefits and costs would be weighed differently, with more emphasis on the positive effect of a robot's sterility. A missing effect on the comfort levels with human caregivers, which ultimately induce the fear of infection we assessed, may also be explained by this account. Ajzen suggests that cognitive attitudes toward an attitudinal object are formed through the strength and (positive or negative) evaluation of each of the anticipated object's outcomes. Since human caregivers are the norm nowadays, one may expect that the beliefs on positive or negative outcomes caused by human caregivers are so numerous that a new piece of information, such as a threat of contagion, would not tilt the balance. By contrast, the balance formed for robotic caregivers may not be as stable yet and may easily be tilted in one or another direction. This idea is supported by Stapels and Eyssel [104], who find that many people's attitudes toward autonomous robots are ambivalent, which means they encompass both strong negative and strong positive evaluations. Hence, these attitudes can tilt into one or the other direction depending on external factors and new information (e.g., a need for protection in a pandemic).

Given the mixed socio-scientific results on the perception of technologies in care contexts [20,24,43,49–63]), it seems complicated to identify any coherent pattern that helps to understand attitudes toward care robots. Identifying drivers that systematically influence the acceptance of robots in this domain is, however, essential if this technology is to be utilized for mitigating the vicious combination of an aging population and a declining willingness to engage in the nursing profession. Our research indicates that the fear of an infection that is likely to depend on a person's internal characteristics as well as on external environmental conditions is such a driver. Complementary to previous studies, these findings emphasize two things. First, it is crucial to avoid projecting one's own intuitions regarding, for instance, inhumane and sterile technologies to other people who might have fewer negative attitudes toward the sterility of robots because their connotations with human closeness are ambivalent. Second, it is crucial to continuously reassess attitudes to technologies because in an age coined by social disruptions like pandemics, attitudes toward the relative value of human and robotic care might be subject to change.

5.1. Limitations and further research potential

One limitation of our study is using a culturally relatively homogeneous convenience sample of US citizens. The transferability of our results to other cultural areas could possibly be limited. While futuristic accounts of robots in pop culture are often dystopian in Western cultures, this is less common, for example, in Japan [105]. Thus, the idea of care robots may not induce negative affective attitudes of the same strength in, for example, Japan because individuals' cultural background is shown to have a significant influence on people's attitudes toward robots and the areas of application and tasks that are conceivable to them [106]. Another limitation of our study is that we provided participants merely with vignettes and a description of a care situation. No elaborate descriptions of the human caregiver or care robot were

provided. Savelle et al. [50] found that studies in which participants were exposed to actual robots tended to identify more overall positive attitudes toward them than studies with hypothetical robots. This suggests that the more concrete a robot becomes for study participants, the more they might ascribe positive evaluations toward it. Taken together, the positive effect of a fear of contagion on comfort levels with a care robot might not be as pronounced in another culture or in studies that expose participants to actual care robots. Comfort levels may overall be higher in these other settings. However, we still expect that the positive effect that a fear of contagion has on the comfort level with care robots transfers to other cultures and study designs, albeit possibly to a lesser degree. Further research is needed to elaborate on these assumptions.

In our vignettes, we aimed to test affective attitudes toward different caregivers *ceteris paribus*. Therefore, to keep the caregivers' descriptions the same, we described hypothetical caregiving situations. In these, robots are mature enough to act fully autonomously and provide the same level of care as human caregivers. Today, however, no such autonomous system exists. Technologies currently used under the term "care robots" often cannot be used by those in need of care without the assistance of another human. As Thunberg and Ziemke [107] show, this can have complex implications for the actual use (or non-use) of care robots, especially during a pandemic, which could severely limit the availability of (human) caregivers. By its nature, a study with hypothetical scenarios cannot capture these effects. Research potential lies in expanding our study to identify implications beyond attitudes on the actual use of care robots. The young average age of our convenience sample compared to the average age of current care recipients might have contributed to them perceiving the described situations as hypothetical. Although the median age (44 years) of our sample was higher than the median age of the US population, which was 38.8 years in 2021 [108], our participants were still much younger than most care recipients. In 2019, the average age of care recipients in the US was 68.4 years, and the median was 72 years [109]. Therefore, the idea of being care-dependent may have felt very remote for most of our participants, as they most likely anticipate facing care dependency only in the distant future.

A related problem may arise from the existence of an intrapersonal empathy gap. This gap causes people to project their current emotional state onto the future and thus underestimate how their views might change [110]. As a result, it may have been challenging for participants to anticipate how they would feel in future care scenarios. However, the temporal distance from an event (i.e., the time between a person's present and that event) affects how it is perceived. For example, when an action lies in the more distant future, arguments in favor of that action seem to be more salient [111]. Therefore, people tend to have a more positive attitude toward that action than when the same action would be in the near future [112]. Thus, our results may be shifted toward more positive attitudes. However, we have no reason to expect that this effect differs systematically between caregivers and scenarios. As we further found no statistically significant differences between conditions regarding participant age, we are confident that our results remain meaningful. Nonetheless, there is interesting research potential in surveying older adults who already need nursing care to assess their perceptions and experiences with assistive technologies and to compare their responses with those of younger and healthier respondents.

Future research should assess people's attitudes and intuitions concerning new technologies on a regular basis. As this study emphasizes, attitudes can change - sometimes even within a short period of time, because of external disruptions. Longitudinal studies may inform about the effects of disruptive events like the COVID-19 pandemic on attitudes toward technological advances. This is especially true for a longitudinal

comparison between countries since such an event does not affect public awareness everywhere simultaneously.³ Technologies about which people have yet to form a stable opinion and about which they are still ambivalent, such as care robots, are prone to changing attitudes. As this study and previous studies during the COVID-19 pandemic have shown, this applies not only to changes toward a more negative attitude concerning a technology but also to more positive ones. Further research is also needed to evaluate whether these effects are lasting, or whether they fade out over time or even reverse.

Our results suggest a causal link between a growing fear of contagion from human caregivers and a higher comfort level with care robots although it might be caused by an unmeasured underlying variable. However, the robustness of the effect that a fear of contagion had on the comfort levels in a scenario with a care robot when controlling for people's general attitudes toward robots supports the assumption that the pandemic fostered the acceptance of care robots in our sample. Further experimental evidence, for example a study design that manipulates the awareness of a possible contagious threat in a randomized subsample systematically, may be needed to validate our hypothesis.

6. Conclusion

Taken together, in line with previous literature, we established that people mostly prefer a human caregiver to a care robot. However, we found evidence for higher comfort levels in a scenario with care robots in people who showed a higher fear of contagion by human caregivers during the pandemic. This effect proved robust when controlling for demographic factors and general attitudes toward robots. For people with a high fear of infection, it even led to comfort levels with a care robot that were equal to those with a human caregiver. Such disruptive external events as the COVID-19 pandemic may sometimes swiftly change people's attitudes toward emerging technologies. This may be true not only for technologies proposed and marketed for the direct combat of a threat, such as virus-tracing apps or surveillance technology to counteract terrorism, but also for technologies that help people to keep and feel safe in more general terms. It is, thus, essential to monitor people's attitudes toward new technologies on a regular basis, especially for those technologies that are contested in the public debate despite promising opportunities to mitigate emerging societal or natural crises. Continually assessing attitudes will help to establish which external factors lead people to more positive conceptions and higher acceptance of these technologies and which kinds of arguments can be inferred and brought into the societal discussion about their deployment.

Declaration of interest

The authors declare no conflict of interest.

Role of the funding source

Funding by the Bavarian Research Institute for Digital Transformation (bidt) is gratefully acknowledged. The funding source had no influence on the design or report of this study.

Credit roles

Manuela Schönmann: Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft, Visualization Anja Bodenschatz: Conceptualization, Methodology, Writing - Review & Editing Matthias Uhl: Conceptualization, Methodology, Writing - Review & Editing, Funding acquisition Gari Walkowitz: Conceptualization,

Methodology, Writing - Review & Editing.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.techsoc.2024.102464>.

References

- [1] D. Arlt, J. Wolling, Fukushima effects in Germany? Changes in media coverage and public opinion on nuclear power, *Publ. Understand. Sci.* 25 (7) (2016) 842–857, <https://doi.org/10.1177/0963662515589276>.
- [2] N. Tsujikawa, S. Tsuchida, T. Shiotani, Changes in the factors influencing public acceptance of nuclear power generation in Japan since the 2011 Fukushima Daiichi nuclear disaster, *Risk Anal.* 36 (1) (2016) 98–113.
- [3] WIN-Gallup International, Impact of Japan Earthquake on Views about Nuclear Energy: Findings from a Global Snap Poll in 47 Countries by WIN-Gallup International, 2011.
- [4] Ø. Ekeberg, B. Fauske, B. Berg-Hansen, Norwegian airline passengers are not more afraid of flying after the terror act of September 11. The flight anxiety, however, is significantly attributed to acts of terrorism, *Scand. J. Psychol.* 55 (5) (2014) 464–468.
- [5] M.F. Floyd, H. Gibson, L. Pennington-Gray, B. Thapa, The effect of risk perceptions on intentions to travel in the aftermath of September 11, 2001, *J. Trav. Tourism Market.* 15 (2–3) (2004) 19–38.
- [6] K. Othman, Impact of autonomous vehicles accidents on the public attitude toward this emerging technology, in: *Proceedings of Fourth International Conference on Communication, Computing and Electronics Systems: ICCCES 2022*, Springer Nature Singapore, Singapore, 2023, March, pp. 527–548.
- [7] B. Steffen, A. Patt, A historical turning point? Early evidence on how the Russia-Ukraine war changes public support for clean energy policies, *Energy Res. Social Sci.* 91 (2022) 102758.
- [8] C. Lüdemann, C. Schlepper, The role of fear in the surveillance state in times of terrorism: Explaining attitudes toward new governmental security measures, *Methods, Theories, and Empirical Applications in the Social Sciences* (2012) 263–270.
- [9] P. MacInnes, The Handshake Is Dead. Long Live the Quick, Clean, Tender Fist Bump, *The Guardian*, 2022, April 22. <https://www.theguardian.com/commentisfree/2022/apr/22/pandemic-fist-bump-barack-obama-covid>.
- [10] H.S. Saetra, The foundations of a policy for the use of social robots in care, *Technol. Soc.* 63 (2020) 101383.
- [11] J. Huber, *Technikbilder: Weltanschauliche Weichenstellungen der Technologie- und Umweltpolitik*, Westdeutscher Verlag, 1989, <https://doi.org/10.1007/978-3-322-84200-8>.
- [12] A. Grunwald, *Living Technology: Philosophy and Ethics at the Crossroads between Life and Technology*, Jenny Stanford Publishing, 2021.
- [13] J. Seifert, O. Friedrich, S. Schleidgen, Imitating the human. New human-machine interactions in social robots, *NanoEthics* 16 (2) (2022) 181–192, <https://doi.org/10.1007/s11569-022-00418-x>.
- [14] OECD, *Health at a Glance 2021: OECD Indicators*, OECD Publishing, 2021, <https://doi.org/10.1787/ae3016b9-en>.
- [15] World Health Organization, *World Report on Ageing and Health*, World Health Organization, 2015.
- [16] United Nations, Department of Economic, Social Affairs, Population Division (Eds.), *World Population Ageing 2019 (ST/ESA/SER.A/444)*, 2020. New York, USA, <https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2019-Report.pdf>.
- [17] OECD, *Society at a Glance 2019: OECD Social Indicators*, OECD Publishing, 2019, https://doi.org/10.1787/soc_glance-2019-en.
- [18] S. Vallor, Carebots and caregivers: sustaining the ethical ideal of care in the twenty-first century, *Philosophy & Technology* 24 (3) (2011) 251–268, <https://doi.org/10.1007/s13347-011-0015-x>.
- [19] F. Stokes, A. Palmer, Artificial intelligence and robotics in nursing: ethics of caring as a guide to dividing tasks between AI and humans, *Nurs. Philos. : An International Journal for Healthcare Professionals* 21 (4) (2020) e12306, <https://doi.org/10.1111/nup.12306>.
- [20] S. Frennert, H. Aminoff, B. Östlund, Technological frames and care robots in eldercare, *International Journal of Social Robotics* (2020), <https://doi.org/10.1007/s12369-020-00641-0>. Advance online publication.
- [21] A. Palmer, D. Schwan, Beneficent dehumanization: employing artificial intelligence and carebots to mitigate shame-induced barriers to medical care, *Bioethics* 36 (2) (2022) 187–193, <https://doi.org/10.1111/bioe.12986>.
- [22] J.P. Boada, B.R. Maestre, C.T. Genís, The ethical issues of social assistive robotics: a critical literature review, *Technol. Soc.* 67 (2021) 101726.
- [23] I. Deutsch, H. Erel, M. Paz, G. Hoffman, O. Zuckerman, Home robotic devices for older adults: opportunities and concerns, *Comput. Hum. Behav.* 98 (2019) 122–133, <https://doi.org/10.1016/j.chb.2019.04.002>.

³ For example, during the COVID-19 Pandemic Japan was closing all schools [116], while in Germany, people were still celebrating the big festival of Carnival.

- [24] S. Lehmann, E. Ruf, S. Misocho, Robot use for older adults – attitudes, wishes and concerns. First results from Switzerland, in: C. Stephanidis, M. Antona (Eds.), *Communications in Computer and Information Science: Vol. 1224, HCI International 2020 - Posters*, Springer, 2020, pp. 64–70, https://doi.org/10.1007/978-3-030-50732-9_9. HCII 2020 (vol. 1226).
- [25] A. Sharkey, N. Sharkey, Granny and the robots: ethical issues in robot care for the elderly, *Ethics Inf. Technol.* 14 (1) (2012) 27–40, <https://doi.org/10.1007/s10676-010-9234-6>.
- [26] R. Sparrow, Robots in aged care: a dystopian future? *AI Soc.* 31 (4) (2016) 445–454, <https://doi.org/10.1007/s00146-015-0625-4>.
- [27] M. Merda, K. Schmidt, B. Kähler, *Pflege 4.0 – Einsatz moderner Technologien aus der Sicht professionell Pflegenden: Forschungsbericht Stand 08/2017*. Hamburg, Berufsgenossenschaft für Gesundheitsdienst und Wohlfahrtspflege, 2017 (BGW).
- [28] I. Papadopoulos, A. Sgorbissa, C. Koulouglioti, Caring Robots Are Here to Help, *Nursing Standard (Royal College of Nursing (Great Britain))*, 2017, pp. 18–20, <https://doi.org/10.7748/ns.31.51.18.s22>, 1987), 31(51).
- [29] I. Wachsmuth, Robots like me: challenges and ethical issues in aged care, *Front. Psychol.* 9 (2018) 432, <https://doi.org/10.3389/fpsyg.2018.00432>.
- [30] T. Sorell, H. Draper, Robot carers, ethics, and older people, *Ethics Inf. Technol.* 16 (2014) 183–195, <https://doi.org/10.1007/s10676-014-9344-7>.
- [31] M. Schönmann, A. Bodenschatz, M. Uhl, G. Walkowitz, The Care-Dependent are Less Averse to Care Robots: An Empirical Comparison of Attitudes, *Int. J. Soc. Robot.* 15 (2023) 1007–1024, <https://doi.org/10.1007/s12369-023-01003-2>.
- [32] M.A. Nowak, A. Sasaki, C. Taylor, D. Fudenberg, Emergence of cooperation and evolutionary stability in finite populations, *Nature* 428 (6983) (2004) 646–650, <https://doi.org/10.1038/nature02414>.
- [33] R. Wright, *Nonzero: the Logic of Human Destiny*, Knopf Doubleday Publishing Group, 2001.
- [34] J.W. Crandall, M. Oudah, T. Tennom, F. Ishowo-Oloko, S. Abdallah, J.-F. Bonnefon, M. Cebrían, A. Shariff, M.A. Goodrich, I. Rahwan, Cooperating with machines, *Nat. Commun.* 9 (1) (2018) 233, <https://doi.org/10.1038/s41467-017-02597-8>.
- [35] F. Ishowo-Oloko, J.-F. Bonnefon, Z. Soroye, J. Crandall, I. Rahwan, T. Rahwan, Behavioural evidence for a transparency–efficiency tradeoff in human–machine cooperation, *Nat. Mach. Intell.* 1 (11) (2019) 517–521, <https://doi.org/10.1038/s42256-019-0113-5>.
- [36] G. Bohner, N. Dickel, Attitudes and attitude change, *Annu. Rev. Psychol.* 62 (2011) 391–417, <https://doi.org/10.1146/annurev.psych.121208.131609>.
- [37] J.M. Olson, M.P. Zanna, Attitudes and attitude change, *Annu. Rev. Psychol.* 44 (1) (1993) 117–154, <https://doi.org/10.1146/annurev.ps.44.020193.001001>.
- [38] I. Ajzen, Nature and operation of attitudes, *Annu. Rev. Psychol.* 52 (2001) 27–58, <https://doi.org/10.1146/annurev.psych.52.1.27>.
- [39] G.R. Maio, G. Haddock, B. Verplanken, *The Psychology of Attitudes & Attitude Change*, Sage, 2019, 3rd edition.
- [40] M. Rokeach, Beliefs, attitudes and values: a theory of organization and change, in: *The Jossey-Bass Behavioral Science Series*, Jossey-Bass, 1968, p. 1.
- [41] S.J. Breckler, Empirical validation of affect, behavior, and cognition as distinct components of attitude, *J. Pers. Soc. Psychol.* 47 (6) (1984) 1191–1205, <https://doi.org/10.1037/0022-3514.47.6.1191>.
- [42] M.A. Olson, R.V. Kendrick, Origins of attitudes, in: W.D. Crano, R. Prislin (Eds.), *Frontiers of Social Psychology. Attitudes and Attitude Change*, Psychology Press, 2008, pp. 111–130.
- [43] S. Naneva, M. Sarda Gou, T.L. Webb, T.J. Prescott, A systematic review of attitudes, anxiety, acceptance, and trust toward social robots, *International Journal of Social Robotics* 12 (6) (2020) 1179–1201, <https://doi.org/10.1007/s12369-020-00659-4>.
- [44] R.L. van Giesen, A.R.H. Fischer, H. van Dijk, H.C.M. van Trijp, Affect and cognition in attitude formation toward familiar and unfamiliar attitude objects, *PLoS One* 10 (10) (2015) e0141790, <https://doi.org/10.1371/journal.pone.0141790>.
- [45] R.B. Zajonc, Feeling and thinking: preferences need no inferences, *Am. Psychol.* 35 (2) (1980) 151–175, <https://doi.org/10.1037/0003-066X.35.2.151>.
- [46] D. Harborth, H. Kreuz, Exploring the attitude formation process of individuals toward new technologies: the case of augmented reality, *Int. J. Technol. Market.* 14 (2) (2020) 125fazi, <https://doi.org/10.1504/IJTMKT.2020.110128>. Article 110128.
- [47] R.F. Bornstein, Exposure and affect: overview and meta-analysis of research, 1968–1987, *Psychol. Bull.* 106 (2) (1989) 265–289, <https://doi.org/10.1037/0033-2909.106.2.265>.
- [48] J. Hansen, M. Wänke, Liking what’s familiar: the importance of unconscious familiarity in the mere-exposure effect, *Soc. Cognit.* 27 (2) (2009) 161–182, <https://doi.org/10.1521/soco.2009.27.2.161>.
- [49] S. Whelan, K. Murphy, E. Barrett, et al., Factors affecting the acceptability of social robots by older adults including people with dementia or cognitive impairment: a literature review, *Int J of Soc Robotics* 10 (2018) 643–668, <https://doi.org/10.1007/s12369-018-0471-x>.
- [50] N. Savelle, T. Turja, A. Oksanen, Social acceptance of robots in different occupational fields: a systematic literature review, *Int J of Soc Robotics* 10 (2018) 493–502, <https://doi.org/10.1007/s12369-017-0452-5>.
- [51] B. Klein, B. Graf, I.F. Schläömer, et al. (Eds.), *Robotik in der Gesundheitswirtschaft: Einsatzfelder und Potenziale, medhochzwei, Heidelberg*, 2018.
- [52] C.-A. Smarr, T.L. Mitzner, J.M. Beer, et al., Domestic robots for older adults: attitudes, preferences, and potential, *Int J of Soc Robotics* 6 (2014) 229–247, <https://doi.org/10.1007/s12369-013-0220-0>.
- [53] D. Saplacan, J. Herstad, Z. Pajalic, An analysis of independent living elderly’s views on robots: a descriptive study from the Norwegian context, in: *ACHI 2020: the Thirteenth International Conference on Advances in Computer-Human Interactions, IARIA, Wilmington, DE, USA*, 2020.
- [54] J.A. Hoppe, O. Tuisku, R.-M. Johansson-Pajala, et al., When do individuals choose care robots over a human caregiver? Insights from a laboratory experiment on choices under uncertainty 9 (2023).
- [55] C. Plaschka, D. Sawchuck, T. Orr, et al., Global policies on assistive robots for care of the elderly: a scoping review, *IJH* 6 (2019) 63, <https://doi.org/10.5430/ijh.v6n1p63>.
- [56] European Commission, *Special Eurobarometer 382: public attitudes toward robots. Digitalisation in Our Daily Lives*, 2012.
- [57] European Commission, *Special Eurobarometer 460: Attitudes toward the Impact of Digitisation and Automation on Daily Life*, 2017 (Brussels).
- [58] European Commission, *Special Eurobarometer 427: Autonomous Systems*, vol. 427, European Commission Directorate General Communication, Brussels, 2015.
- [59] A. Smith, M. Anderson, *Automation in Everyday Life*, 2017.
- [60] I. Honekamp, L. Sauer, T. Wache, et al., Akzeptanz von Pflegerobotern im Krankenhaus, *TATuP* 28 (2019) 58–63, <https://doi.org/10.14512/tatup.28.2.s58>.
- [61] L. Pigni, D. Facal, L. Blasi, et al., Service robots in elderly care at home: users’ needs and perceptions as a basis for concept development, *Technol. Disabil.* 24 (2012) 303–311, <https://doi.org/10.3233/TAD-120361>.
- [62] B. Graf, T. Jacobs, Einsatzpotenziale und Erfahrungen aus der Erprobung von Servicerobotern in stationären Altenpflegeeinrichtungen: opportunities and experiences of applying service robots in residential elderly care facilities, in: R. Wichert, B. Eberhardt (Eds.), *Ambient Assisted Living: 5. AAL-Kongress 2012 Berlin, Germany, January 24-25, 2012, Aufl. 2012*, Springer Berlin, Berlin, 2014.
- [63] S. Łukasik, S. Tobis, S. Kropińska, et al., Role of assistive robots in the care of older people: survey study among medical and nursing students, *J. Med. Internet Res.* 22 (2020) e18003, <https://doi.org/10.2196/18003>.
- [64] P.G. Zimbardo, M.R. Leippe, *The Psychology of Attitude Change and Social Influence*, Temple University Press, 1991.
- [65] D. Albarracín, S. Shavitt, Attitudes and attitude change, *Annu. Rev. Psychol.* 69 (2018) 299–327, <https://doi.org/10.1146/annurev-psych-122216-011911>.
- [66] M. Rokeach, Introduction, in: M. Rokeach (Ed.), *Understanding Human Values: Individual and Societal*, Free Pr, 1979, pp. 1–14.
- [67] S. Hitlin, Values as the core of personal identity: drawing links between two theories of self, *Soc. Psychol. Q.* (2003) 118–137.
- [68] C. Milchram, G. Van de Kaa, N. Doorn, R. Künneke, Moral values as factors for social acceptance of smart grid technologies, *Sustainability* 10 (8) (2018) 2703.
- [69] S. Sun, P.C. Lee, R. Law, L. Zhong, The impact of cultural values on the acceptance of hotel technology adoption from the perspective of hotel employees, *J. Hospit. Tourism Manag.* 44 (2020) 61–69.
- [70] T. Turja, S. Taipale, M. Niemelä, T. Oinas, Positive turn in elder-care workers’ views toward telecare robots, *International journal of social robotics* 14 (4) (2022) 931–944.
- [71] M. Hofer, H. Reinders, S. Fries, Wie sich die Werte ändern, *Z. für Entwicklungspsychol. Pädagogische Psychol.* 42 (1) (2010) 26–38, <https://doi.org/10.1026/0049-8637/a000003>.
- [72] L.A. Rudman, M.C. McLean, M. Bunzl, When truth is personally inconvenient, attitudes change: the impact of extreme weather on implicit support for green politicians and explicit climate-change beliefs, *Psychol. Sci.* 24 (11) (2013) 2290–2296, <https://doi.org/10.1177/0956797613492775>.
- [73] P. Milojev, L. Greaves, D. Osborne, C.G. Sibley, Stability and change in political conservatism following the global financial crisis, *Pers. Soc. Psychol. Bull.* 41 (1) (2015) 127–139, <https://doi.org/10.1177/0146167214559710>.
- [74] W. Bleidorn, T. Schwaba, C.J. Hopwood, Health adversity and value change, *Soc. Psychol. Personal. Sci.* 12 (2) (2021) 248–257, <https://doi.org/10.1177/1948550620901980>.
- [75] J.-E. Lönnqvist, I. Jasinskaja-Lahti, M. Verkasalo, Rebound effect in personal values, *J. Cross Cult. Psychol.* 44 (7) (2013) 1122–1126, <https://doi.org/10.1177/0022022113480040>.
- [76] M. Verkasalo, R. Goodwin, I. Bezmenova, Values following a major terrorist incident: Finnish adolescent and student values before and after september 11, 2001, *J. Appl. Soc. Psychol.* 36 (1) (2006) 144–160, <https://doi.org/10.1111/j.0021-9029.2006.00007.x>.
- [77] E. Daniel, K. Fortuna, S.K. Thrun, S. Cioban, A. Knafo, Brief report: early adolescents’ value development at war time, *J. Adolesc.* 36 (4) (2013) 651–655, <https://doi.org/10.1016/j.adolescence.2013.03.009>.
- [78] F.M. Sortheix, P.D. Parker, C.M. Lechner, S.H. Schwartz, Changes in young Europeans’ values during the global financial crisis, *Soc. Psychol. Personal. Sci.* 10 (1) (2019) 15–25, <https://doi.org/10.1177/1948550617732610>.
- [79] S.H. Schwartz, Universals in the content and structure of values: theoretical advances and empirical tests in 20 countries, *Advances in Experimental Social Psychology* Volume 25, Adv. Exp. Soc. Psychol. 25 (1992) 1–65, [https://doi.org/10.1016/S0065-2601\(08\)60281-6](https://doi.org/10.1016/S0065-2601(08)60281-6). Elsevier.
- [80] S. Steinert, Corona and value change. The role of social media and emotional contagion, *Ethics Inf. Technol.* (2020) 59–68, <https://doi.org/10.1007/s10676-020-09545-z>.
- [81] Economic Research Institute for ASEAN and East Asia, *Public Perception and Acceptance of Nuclear Power: Stakeholder Issues and Community Solutions (ERIA Research Project Report FY2020 No. 08)*, 2020 (Jakarta).
- [82] OECD, *Public Attitudes to Nuclear Power: Nuclear Development*. Nuclear Development: NEA No. 6859, OECD Publishing, 2010, <https://doi.org/10.1787/9789264097933-en>.
- [83] G. Prati, B. Zani, The effect of the Fukushima nuclear accident on risk perception, antinuclear behavioral intentions, attitude, trust, environmental beliefs, and

- values, *Environ. Behav.* 45 (6) (2013) 782–798, <https://doi.org/10.1177/0013916512444286>.
- [84] E. Park, J.Y. Ohm, Factors influencing the public intention to use renewable energy technologies in South Korea: effects of the Fukushima nuclear accident, *Energy Pol.* 65 (2014) 198–211, <https://doi.org/10.1016/j.enpol.2013.10.037>.
- [85] C.M. Coelho, P. Suttiwan, N. Arato, A.N. Zsido, On the nature of fear and anxiety triggered by COVID-19, *Front. Psychol.* 11 (2020) 1–8, <https://doi.org/10.3389/fpsyg.2020.581314>. Article 581314.
- [86] S. Quadros, S. Garg, R. Ranjan, G. Vijayarathi, M.A. Mamun, Fear of covid 19 infection across different cohorts: a scoping review, *Front. Psychiatr.* 12 (2021) 708430, <https://doi.org/10.3389/fpsyg.2021.708430>.
- [87] World Health Organization, Advice for the Public: Coronavirus Disease (COVID-19), 2022, May 10. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public>.
- [88] A. Sixsmith, B.R. Horst, D. Simeonov, A. Mihailidis, Older people's use of digital technology during the COVID-19 pandemic, *Bull. Sci. Technol. Soc.* 42 (1–2) (2022) 19–24, <https://doi.org/10.1177/02704676221094731>.
- [89] J.M. Barrutia, C. Echebarria, Effect of the COVID-19 pandemic on public managers' attitudes toward digital transformation, *Technol. Soc.* 67 (2021) 101776, <https://doi.org/10.1016/j.techsoc.2021.101776>.
- [90] I.A. Novikova, P.A. Bychkova, A.L. Novikov, Attitudes toward digital educational technologies among Russian university students before and during the COVID-19 pandemic, *Sustainability* 14 (10) (2022) 6203, <https://doi.org/10.3390/su14106203>.
- [91] A. Bojanowska, Ł.D. Kaczmarek, M. Koscielniak, B. Urbańska, Changes in values and well-being amidst the COVID-19 pandemic in Poland, *PLoS One* 16 (9) (2021) e0255491, <https://doi.org/10.1371/journal.pone.0255491>.
- [92] E. Daniel, A. Bardi, R. Fischer, M. Benish-Weisman, J.A. Lee, Changes in personal values in pandemic times, *Soc. Psychol. Personal. Sci.* 13 (2) (2022) 572–582, <https://doi.org/10.1177/19485506211024026>.
- [93] A. Penner, F. Eyssel, Germ-free robotic friends: Loneliness during the COVID-19 pandemic enhanced the willingness to self-disclose toward robots, *Robotics* 11 (6) (2022) 121, <https://doi.org/10.3390/robotics11060121>.
- [94] A. Wnuk, T. Oleksy, D. Maison, The acceptance of Covid-19 tracking technologies: the role of perceived threat, lack of control, and ideological beliefs, *PLoS One* 15 (9) (2020) e0238973, <https://doi.org/10.1371/journal.pone.0238973>.
- [95] M. Heerink, B. Kröse, V. Evers, B. Wielinga, Assessing acceptance of assistive social agent technology by older adults: the almere model, *International Journal of Social Robotics* 2 (4) (2010) 361–375, <https://doi.org/10.1007/s12369-010-0068-5>.
- [96] R. Hughes, M. Huby, The application of vignettes in social and nursing research, *J. Adv. Nurs.* 37 (4) (2002) 382–386, <https://doi.org/10.1046/j.1365-2648.2002.02100.x>.
- [97] C. Barter, E. Renold, The use of vignettes in qualitative research, *Soc. Res. Update* 25 (1999) 1–4. <https://sru.soc.surrey.ac.uk/SRU25.html>.
- [98] T. Turja, L. van Aershot, T. Särkikoski, A. Oksanen, Finnish healthcare professionals' attitudes toward robots: reflections on a population sample, *Nursing Open* 5 (3) (2018) 300–309, <https://doi.org/10.1002/nop2.138>.
- [99] T. Nomura, T. Suzuki, T. Kanda, K. Kato, Measurement of negative attitudes toward robots, *Interact. Stud.* 7 (3) (2006) 437–454, <https://doi.org/10.1075/is.7.3.14nom>.
- [100] C.U. Krägeloh, J. Bharatharaj, S.K. Sasthan Kutty, P.R. Nirmala, L. Huang, Questionnaires to measure acceptability of social robots: a critical review, *Robotics* 8 (4) (2019) 88, <https://doi.org/10.3390/robotics8040088>.
- [101] D.J. Leiner, SoSci Survey, 2020 [Computer software], Version 3.2.12. <http://www.sosocisurvey.de>.
- [102] J. Chandler, C. Rosenzweig, A.J. Moss, J. Robinson, L. Litman, Online panels in social science research: expanding sampling methods beyond Mechanical Turk, *Behav. Res. Methods* 51 (5) (2019) 2022–2038, <https://doi.org/10.3758/s13428-019-01273-7>.
- [103] L. Aymerich-Franch, I. Ferrer, Liaison, safeguard, and well-being: analyzing the role of social robots during the COVID-19 pandemic, *Technol. Soc.* 70 (2022) 101993.
- [104] J.G. Stapels, F. Eyssel, Robocalypse? yes, please! the role of robot autonomy in the development of ambivalent attitudes toward robots, *International Journal of Social Robotics* 14 (3) (2022) 683–697, <https://doi.org/10.1007/s12369-021-00817-2>.
- [105] C. Bartneck, T. Suzuki, T. Kanda, T. Nomura, The influence of people's culture and prior experiences with Aibo on their attitude toward robots, *AI Soc.* 21 (2007) 217–230, <https://doi.org/10.1007/s00146-006-0052-7>.
- [106] I. Papadopoulos, C. Koulouglioti, The influence of culture on attitudes toward humanoid and animal-like robots: an integrative review, *J. Nurs. Scholarsh.* 50 (2018) 653–665, <https://doi.org/10.1111/jnu.12422>.
- [107] S. Thunberg, T. Ziemke, Pandemic effects on social companion robot use in care homes, in: 2021 30th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), IEEE, 2021, pp. 983–988, <https://doi.org/10.1109/RO-MAN50785.2021.9515465>.
- [108] United States Census Bureau, Median Age of the Resident Population of the United States from 1960 to 2021. Graph, 2022. <https://www.statista.com/statistics/241494/median-age-of-the-us-population/>. (Accessed 10 October 2023).
- [109] Aarp, National Alliance for Caregiving, Caregiving in the United States 2020: Research Report, AARP, Washington, DC, 2020.
- [110] G. Loewenstein, T. O'Donoghue, M. Rabin, Projection bias in predicting future utility, *Q. J. Econ.* 118 (2003) 1209–1248, <https://doi.org/10.1162/00335530322552784>.
- [111] N. Liberman, T. Eyal, Y. Trope, et al., The pros and cons of temporally near and distant action, *J. Pers. Soc. Psychol.* 86 (2004) 781–795, <https://doi.org/10.1037/0022-3514.86.6.781>.
- [112] S.M. Herzog, J. Hansen, M. Wänke, Temporal distance and ease of retrieval, *J. Exp. Soc. Psychol.* 43 (2007) 483–488, <https://doi.org/10.1016/j.jesp.2006.05.008>.
- [113] N. Piçarra, J.-C. Giger, G. Pochwatko, G. Gonçalves, Validation of the Portuguese version of the negative attitudes toward robots scale, *Eur. Rev. Appl. Psychol.* 65 (2) (2015) 93–104, <https://doi.org/10.1016/j.erap.2014.11.002>.
- [114] G. Pochwatko, J.-C. Giger, M. Rózańska-Walczyk, J. Świdrak, K. Kukielka, J. Możaryn, N. Piçarra, Polish version of the negative attitude toward robots scale (NARS-PL), *Journal of Automation, Mobile Robotics & Intelligent Systems* 9 (3) (2015) 65–72, https://doi.org/10.14313/JAMRIS_3-2015/25.
- [115] D.S. Syrdal, K. Dautenhahn, K.L. Koay, M.L. Walters, The negative attitudes toward robots scale and reactions to robot behaviour in a live human-robot interaction study, in: 23rd Convention of the Society for the Study of Artificial Intelligence and Simulation of Behaviour, AISB 2009, Edinburgh, United Kingdom, 2009.
- [116] M. Rich, B. Dooley, M. Inoue, Japan shocks parents by moving to close all schools over coronavirus, *The New York Times* (2020). <https://www.nytimes.com/2020/02/27/world/asia/japan-schools-coronavirus.html>.