Patients' Trust in Hospital Transport Robots: Evaluation of the Role of User Dispositions, Anxiety, and Robot Characteristics

Mareike Schüle*
Tech. & Innovation Center
KUKA Deutschland GmbH
Augsburg, Germany
mareike.schuele@kuka.com

Johannes Maria Kraus*
Dept. Human Factors
Ulm University
Ulm, Germany
johannes.kraus@uni-ulm.de

Franziska Babel
Dept. Human Factors
Ulm University
Ulm, Germany
franziska.babel@uni-ulm.de

Nadine Reißner
Tech. & Innovation Center
KUKA Deutschland GmbH
Augsburg, Germany
nadine.reissner@kuka.com

***Abstract*—For designing the interaction with robots in healthcare scenarios, understanding how trust develops in such situations characterized by vulnerability and uncertainty is important. The goal of this study was to investigate how technology-related user dispositions, anxiety, and robot characteristics influence trust. A second goal was to substantiate the association between hospital patients' trust and their intention to use a transport robot. In an online study, patients, who were currently treated in hospitals, were introduced to the concept of a transport robot with both written and video-based material. Participants evaluated the robot several times. Technology-related user dispositions were found to be essentially associated with trust and the intention to use. Furthermore, hospital patients' anxiety was negatively associated with the intention to use. This relationship was mediated by trust. Moreover, no effects of the manipulated robot characteristics were found. In conclusion, for a successful implementation of robots in hospital settings patients' individual prior learning history – e.g., in terms of existing robot attitudes – and anxiety levels should be considered during the introduction and implementation phase.**

***Keywords*—trust, anxiety, intention to use, transport robot, user dispositions, user states, predictability, control**

I. Introduction

The healthcare domain is among the domains, in which service robots can truly help to improve society by providing a solution for the severe workforce gap (e.g., [1, 2]). In this area, there are many different applications in which robots can establish considerable improvements – for both patients and healthcare workers. In the past years, robots have been developed to provide initial support for elderly people, children on the autism spectrum, and other mentally or physically handicapped individuals (for an overview see [3]). In the future, robots might further extend their functional scope by conducting medical procedures like measurements (e.g., [4]) or supporting patients on a social level (e.g., [5]). While for many of these tasks the current state of robot technology is not at a level to ensure robust functioning, individual transport of patients in hospital facilities already constitutes a technically realistic use case. At the same time, the introduction of robots in the hospital setting introduces ethical challenges for patients' well-being, safety as well as acceptance [3, 6]. Especially in a situation of hospitalization which is already commonly associated with increased levels of anxiety [7–9], the reduction of negative psychological reactions to robots is an important goal. As state anxiety was found to be a predictor for trust in automated systems (e.g., [10]) and service robots in specific [11] the reduction and prevention of patients' anxiety is essential for facilitating the adoption of robots in healthcare.

Against this background, the overall research goal of this study was to provide a deeper understanding of how patients' trust in a newly introduced transportation robot is built up. In an online setup, this study further explored the dynamic relationship between state anxiety, trust, and the intention to use a robot. Furthermore, to provide a better understanding for the underlying psychological mechanisms in which anxiety and trust are formed in such situations, the role of individual user dispositions was investigated. To inspire potential design solutions for limiting negative experiences the role of robot predictability and controllability was investigated.

II. Related Work

A. Trust in Robots in a Healthcare Context

Robots are complex automated technical systems, which pose the challenge to deal with them on the basis of restricted prior experience and reduced transparency of system functioning. This is especially the case with robots in the healthcare setting, in which patients might tend to feel even less in control and more vulnerable, thus underlining the important role of trust in these contexts. Trust in robots is theoretically rooted in the broader concept of trust in automation (e.g., [12, 13]), which was defined *'as the attitude that an agent will help achieve an individual's goals in a situation characterized by uncertainty and vulnerability'* [14, p. 51]. In HRI, this agent is a robot. The dynamic formation of trust in the process of getting to know a newly introduced robot is an important research area to guide user-centered and ethical design of robots (e.g., [15]). Trust as a dynamic variable is affected by different variable groups in a dynamic learning process over time. Thereby, the goal of robot design is not to increase trust to a maximum, but rather to facilitate a calibrated level of trust reflecting a robot's actual capabilities and limitations (e.g., [14]). This research addresses psychological processes involved in the dynamic formation of trust in a robot developed in the PeTRA project. The latter has the goal to develop a robotic support system for patient transport in hospital settings [16]. Accordingly,

*Both authors contributed equally to this research.

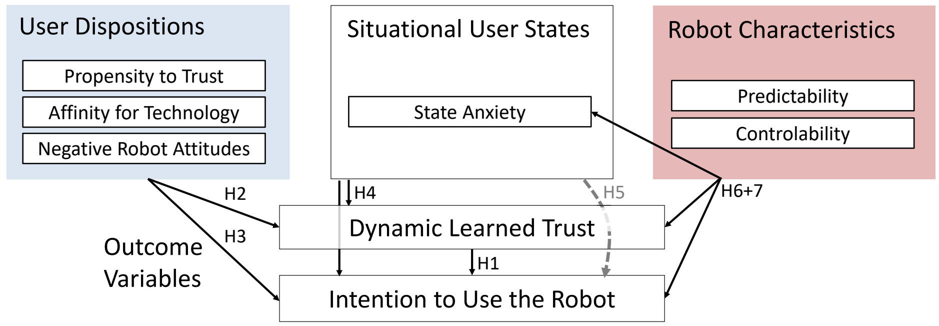

Fig. 1. The investigated three variable groups hypothesized to influence trust in robots and usage intention.The dashed line indicates a mediation.

calibrated trust in the case of the PeTRA robot would facilitate a reliance pattern, in which the robot is only used when it actually allows safe and efficient transportation. In this scenario, especially patients' predispositions regarding technology and robots and the associated feeling of anxiety might play an important role for the psychological processes involved in calibrating trust. To get a scientific understanding of how dispositional and state variables affect the trust formation in health settings, the nature of psychological processes, in which trust is established, needs to be considered.

To reflect the complexity of the psychological process in which trust is built up and calibrated, theoretical considerations and study design benefit from orientation on the current state of trust theory. This research is based on Kraus' Three Stages of Trust framework [15], which proposes three trust layers that build on each other. At the first stage, the propensity to trust refers to an individual disposition to trust automated technology in a broad variety of situations and contexts (see also dispositional trust e.g., in [17]). At this first stage, trust is hypothesized to be established by the individual learning history with technology and individual dispositions like personality and attitudes [15]. The propensity to trust which is general for automated systems influences the use and interpretation of information at the second and third stage. Learned trust in an automated system – e.g., a transportation robot – is established on the basis of available information about the system. Prior to the actual interaction with a system, initial learned trust (stage 2) is formed on the basis of prior available system information like advertising or user manuals. On this basis, during the interaction, trust is assumed to be dynamically updated at the third stage along with information perceived and evaluated during system use like system performance, functionality, and reliability (dynamic learned trust). In accordance with reviews about trust in automation/robots (e.g., [12]), influencing factors in the process of trust formation are grouped in person-, situation-, and system-related variables. An essential assumption of the Three Stages of Trust framework is that these variable groups influence the psychological process of trust formation and calibration at the three stages of trust formation.

At this point, research on the role of user characteristics in the psychological process of the formation of trust in robots is still scarce (e.g., [18]). A promising direction for enhancing conceptual clarity regarding personality foundations of trust processes is a distinction between traits and states (see e.g., [11]). While states are rather short-term adaptations to situational circumstances (e.g., affect [19]), traits represent personal characteristics which are stable over different contexts. Trust formation and calibration have been found to be essentially influenced by both user traits and states (e.g., [10, 11, 20]). In addition to personality traits, technology-related attitudes have been found to be a rather stable source of interindividual differences to approach robots (e.g., [21–23]). On the basis of the Three Stages of Trust framework, it can be assumed that personality traits, attitudes as well as states essentially influence the perception, interpretation, and use of provided information about a robot (or perceived robot behavior) in the process of learning to trust (see also [24]).

In the current study, the role of several user dispositions, a user state, and two robot characteristics were investigated (see Fig. 1). Accordingly, in the study design, trust in the PeTRA robot was measured repeatedly over time. Overall, an association between trust in the robot and the behavioral intention to use this robot was expected (H1).

B. *User Dispositions and Trust in HRI*

In this study, two technology-specific personality traits (the propensity to trust in automation and affinity for technology) as well as prior attitudes towards robots were included to predict differences in dynamic learned trust in the transportation robot (H2) and the intention to use this robot (H3).

The propensity to trust was defined as '*an individual's overall tendency to trust automation, independent of context or a specific system*' [17, p. 413]. In line with the Three Stages of Trust framework, the propensity to trust is hypothesized to essentially influence learned trust during the familiarization with the transportation robot. Users who in general are more prone to trust automation are likely to perceive a newly introduced robot as more trustworthy. Such a relationship gained support by findings in the domain of other automated systems (e.g., [20, 25, 26]) and HRI (e.g., [11, 27]).

As a second trait, the affinity for technology – the individual tendency for enthusiasm, interest, acceptance and active engagement in technology interaction [28, 29] – was included in the study. It can be expected that people with a comparably high affinity for technology are more optimistic about new technology and put more weight on benefits than risks when approaching it and thus feel less anxious and tend to trust it more. In line with this, Franke et al. [28] report higher control beliefs in people with higher affinity for technology. Also, Kraus et al. [24] found considerably high positive correlations both with the propensity to trust in automation and dynamic learned trust in an automated driving system.

Moreover, negative attitudes towards robots were investigated as a potential predictor for anxiety and trust in this study. The role of prior attitudes towards automation for trust was supported in studies from the domains of automated driving (e.g., [25, 26]) and HRI (e.g., [21, 22, 27, 30–32]). Miller et al. [11] found a negative relationship between negative robot attitudes and initial and dynamic learned trust in an experimental real-life study with the humanoid robot TIAGo (PAL Robotics).

C. *User States Affecting Trust in HRI*

State anxiety was defined as *'subjective, consciously perceived feelings of apprehension and tension, accompanied by or associated with activation or arousal of the autonomic nervous system'* [33, p. 17]. According to the affect-as-information model (e.g., [34]), people use their affect as a source for their judgement. Such a process has gained substantial support in human interaction for the role of emotional and affective states on various attentional, perceptive, judgmental, and behavioral outcomes (e.g., [35, 36]). In line with these findings, also in HRI, it can be assumed that the current emotional state considerably affects the experiences, evaluations, and adoption of users getting to know a new system. On this basis, it was hypothesized that the individual level of state anxiety prior to and during the interaction with a robot is related to learned trust (H4). Furthermore, it was hypothesized that state anxiety would also affect the intention to use the robot and that this effect is at least to some part mediated through trust (H5). The role of emotional states for trust was discussed (e.g. [37]) and supported in interpersonal settings (e.g. [38]) as well as in the interaction with automated systems. Kraus et al. [10] found that state anxiety was negatively related to learned trust in an automated driving system. In the context of HRI, Miller et al. [11] reported similar findings for trust in a domestic service robot. Also, Bender et al. [39] supported the hypothesized association between anxiety and trust.

D. *Predictable and Controllable Robot Behavior for Reducing Anxiety*

The experience of unpredictable and uncontrollable events is commonly linked to negative emotional reactions like anxiety (e.g., [40–43]). For example, Grillon et al. [44] found that unpredictable shocks evoke a more anxious reaction than predictable shocks that are announced by a signal. Perceived control is influenced by information, choice, and predictability in turn [45]. In line with this, it was expected that a predictable (i.e., the robot communicates its current and future behavior) and controllable (i.e., the robot offers patients a choice) robot behavior mitigates anxious reactions of hospital patients, which consequently affects trust and the intention to use (H6, H7).

Such a relationship was supported in a study on autonomous driving in which drivers' anxiety was decreased by an alert before the autonomous vehicle breaks [46]. However, Du et al. [47] could not show such an association between prior information and anxiety. Yet, they found a positive association between prior information and trust in the autonomous vehicle. Moreover, in the field of HRI, increased perceptions of predictability and increased trust ratings were found when a robot provided information about current and future actions [4]. Further, in HRI, it was discussed if control could lead to beneficial effects. For example, when offering elderly users a choice, they might perceive more autonomy and control which could in turn positively impact their perceived health control [48]. A respective association of perceptions of control and less negative robot ratings was observed in HRI before [49]. Yet, Fischer et al. [4] did not find clear positive effects in trust evoked by a responsive medical robot that adapted to the user's needs.

E. *Hypotheses*

The following hypotheses are derived from the proposed variable interrelations in the Three Stages of Trust Framework as well as Figure 1 and the previous discussion of related work.

H1: Trust in a hospital transportation robot is positively associated with patients' intention to use this robot for their own transport in the hospital.

H2: The propensity to trust is positively (H2.1), affinity for technology is positively (H2.2) and negative attitudes towards robots are negatively (H2.3) related to trust in a hospital transportation robot.

H3: The propensity to trust is positively (H3.1), affinity for technology is positively (H3.2) and negative attitudes towards robots are negatively (H3.3) related to patients' intention to use the transport robot.

H4: State anxiety is negatively related to trust in a hospital transportation robot (H4.1) and the intention to use this robot (H4.2).

H5: The relationship of state anxiety and patients' intention to use the robot is mediated by trust in the hospital transportation robot.

H6: Predictable robot behavior leads to lower (decreased) state anxiety (H6.1), higher (increased) trust in a hospital transport robot (H6.2), and higher (increased) intention to use (H6.3) compared to unpredictable robot behavior.

H7: Controllable robot behavior leads to lower (decreased) state anxiety (H7.1), higher (increased) trust in a hospital transport robot (H7.2), and higher (increased) intention to use (H7.3) compared to uncontrollable robot behavior.

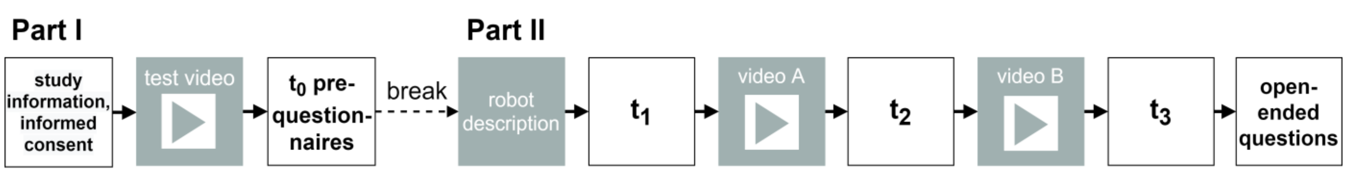

Fig. 2. Study procedure. The online study consisted of two parts. The first part consisted of the study information, the test video and pre-questionnaires. The second part entailed the robot description and the two videos, each followed by questionnaires. t = time of measurement.

III. METHOD

The hypotheses were investigated in an online study with hospital patients. During the questionnaire, to simulate the process of robot familiarization, successively more information about the robot was presented to the patients (see Fig. 2). After a first description of the robot, two videos were presented of which the first one showed a standardized situation of using the robot and the second one showed a similar situation with the manipulation of predictability and controllability.

A. Participants

An a priori G*Power analysis [50] was conducted based on a medium effect size (Cohen's d = .67, η2 = .10 found for robot factors [12]). Assuming a one-way ANOVA with three groups, a minimum sample of N = 90 was indicated. Eligibility criteria were German-speaking, over 18 years, and full legal capacity. Additionally, wheelchair transport had to be feasible and appropriate for possible participants. They further had to be able to concentrate for at least 20 minutes. Patients with impaired consciousness or judgment as well as those who had surgery at the day of the survey were not included. In total, 96 participants completed the study. Four participants had to be excluded. One participant was excluded because of a completion time below 40% of the median duration for answering the questionnaire (as discussed by [51]). One of the excluded participants answered an attention check item ('I try to read the questions in this questionnaire carefully.') with low agreement. Two further participants repeatedly did not show variance in their responses even for reversed items. The final sample size was N = 92. Of those, 59 participants were male and 33 were female. The mean age was 52 years (SD = 15) with a range from 18 to 82 years.

B. Study Design

H1 to H5 were investigated in a correlative design in which variables were assessed at four points of measurement (t_0, t_1, t_2, t_3; see Fig. 2). H6 and H7 were investigated in a video-based experimental procedure, in which the controllability and predictability of the robot were manipulated in three conditions. In the first video (video A), no manipulation of predictability and control was conducted, i.e., all participants experienced unpredictable and uncontrollable robot behavior. In the second video (video B), participants were randomly assigned to one of three different conditions and watched three different versions of the video differing in predictability and controllability:

- Participants of *condition I* experienced *unpredictable and uncontrollable* robot behavior like in video A.
- Participants of *condition II* experienced *predictable and uncontrollable* robot behavior. Thereby, the transport robot communicated intentions about changes in its status (e.g., changing direction, using an elevator).
- Participants of *condition III* experienced *predictable and controllable* robot behavior. Thereby, the transport robot communicated intentions about changes in its status and additionally, participants could make choices (e.g., regarding the route).

To avoid illogical pairing of robot characteristics, the fourth possible condition (unpredictable and controllable) was not implemented in the design, resulting in an incomplete between-group design. In line with H6 and H7, it was expected that the study conditions would lead to differences in state anxiety, trust in automation, and intention to use measured after participants watched video B (t_3). Moreover, it was expected that there would be significant differences when comparing those measurements to the measurements that were conducted after all participants watched video A (t_2).

C. Material

1) Questionnaires

In the study, the questionnaires were completed as indicated in Table I. When available, validated scales and German translations were used. Dispositional variables and state anxiety were assessed at t_0, dependent variables at $t_{1\text{-}3}$. From the NARS (measuring negative attitudes towards robots) only the two subscales concerning interaction with robots and emotions were used. All items were assessed with 7-point Likert scales from 1 = *'not agree at all'* to 7 = *'totally agree'*. Cronbach's alphas of the scales used indicated an overall high internal consistency (see Table I.). Although the alpha values of perceived predictability and control at t_2 were comparably low, the alpha values at t_3 supported internal consistency of these scales. The

TABLE I. QUESTIONNAIRES USED IN THE STUDY

Variable	**Description and Reference**	**α (for each measurement)**			
		t_0	**t_1**	**t_2**	**t_3**
Affinity for technology	shortened 9-item version of the TA-EG [59]	.84	/	/	/
Propensity to trust	translated version of the Propensity to Trust Scale [24], 6 items	.81	/	/	/
Negative attitudes towards robots	translated versions of the two subscales of the NARS [21]:				
	• *negative attitude toward situations of interaction with robots* (6 items)	.77	/	/	/
	• *negative attitude toward emotions in interaction of robots* (3 items)	.84	/	/	/
State anxiety	5-item shortscale STAI-SKD [60]	.90	.94	.95	.96
Trust in automation	5-item short scale LETRAS-G [15]	/	.83	.90	.91
Intention to use	own development based on [61], 4 items (e.g., 'If the transport robot was available in the hospital in the future, I would like to use it.')	/	.91	.93	.89
Perceived predictability	own development, 3 items (e.g., 'I knew exactly what would happen next in the situation.')	/	/	.58	.80
Perceived control	adapted and translated 5-item version of the mastery scale [62]	/	/	.77	.83

Note. Reliability coefficients are provided for all questionnaires when a measurement was conducted at the corresponding measurement point.

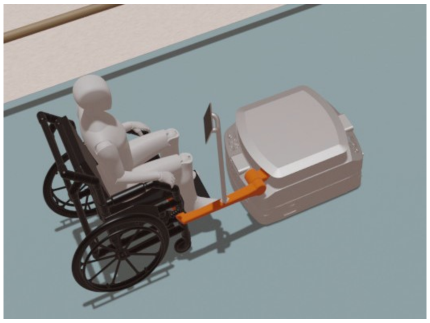

Fig. 3. Animated illustration of the PeTRA transport robot transporting a patient in a wheelchair that was used as a study stimulus.

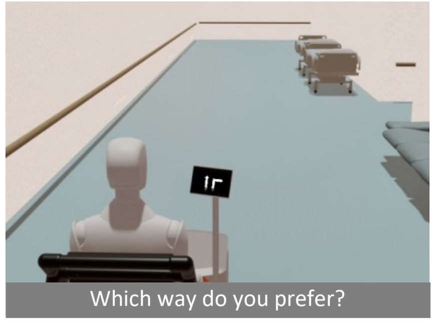

Fig. 4. Screenshot of video B in condition III (predictable and controllable) when the transport robot provides two different route options.

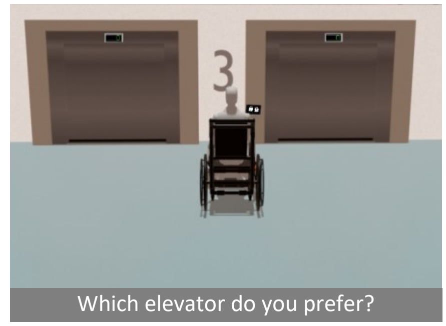

Fig. 5. Screenshot of video B in condition III (predictable and controllable) when the transport robot provides two different elevator options.

low values at t_2 might indicate that participants had difficulties answering the questionnaires after watching the first video in which the robot did not behave predictable or controllable.

2) Robot Description and Video Stimuli

Pictures and videos were created using Blender 2.90 [52]. Altogether, the study procedure for each participant included one robot description and two robot videos. The robot description included written and visual information about the transport robot's development status, functionality, appearance, and safety. The videos showed an animated patient in a wheelchair, who is transported by the robot in a hospital corridor (see Fig. 3). In video B, participants watched one of three versions of the video according to their study group. In the predictable conditions (condition II and III), the transport robot communicated intentions about changes in its status (e.g., turning to the right) by indicating them on a display and by using subtitles in the video. The participants were instructed that the subtitles appear when the robot is talking to them. In the controllable condition III, the robot provided a choice in two situations that allowed two equivalent options to reach the destination: First, there were two route options with the same length (right or straight forward, see Fig. 4) and second there were two elevators (left or right, see Fig. 5) that could be used. In condition III, participants could select one of the options in each situation. In condition I and II, the options were selected randomly. The differences of the three video conditions can be seen in the attached video.

D. Procedure

The study was conducted in the first quarter of 2021 with EFS Survey [53]. Participants were recruited at three German hospitals (Universitätsklinikum Augsburg, Krankenhaus Barmherzige Brüder München, Krankenhaus Martha-Maria Nürnberg) by an invitation on their food tray or a verbal invitation by the staff. Participants could win one of three € 30 shopping vouchers. Ethical approval for this study was obtained from the ethics committee of Ulm University. The questionnaire was answered either with a provided tablet (84%) or a private device (16%). The median duration of the questionnaire was 60 minutes. To avoid too much stress for the participants, the questionnaire was split into two parts, with a break of up to one hour in between. Moreover, patients were encouraged to take as many breaks as necessary.

An overview of the study procedure is provided in Fig. 2. In questionnaire part I, participants received information about the study, confirmed their consent, and in case a private device was used, it was tested if videos could be displayed. At t_0, several pre-questionnaires were answered (i.e., technology-related dispositions and a baseline measurement of state anxiety). Moreover, demographic data, hospitalization, and health status data, as well as further personality traits were assessed, which are not in the scope of this research. In questionnaire part II, the different robot stimuli (robot description and robot videos A and B) were shown, and after each piece of information, at t_1, t_2, and t_3, the outcome variables were measured. Besides the questionnaires described in Table I, acceptance and user preference were measured as additional outcome variables, which are not in the scope of this research. Manipulation checks for predictability and control were only conducted at t_2 and t_3 after participants observed actual robot behavior in a video stimulus. After completing all measurement points, participants were asked to answer several open-ended questions about the transport robot.

IV. Results

Statistical analyses were conducted with R (version 3.5.1). The associations hypothesized in H1-4 were inspected with bivariate Pearson correlations. Since most of the investigated variables were not normally distributed, significance tests for the correlation coefficients might be biased [54]. To avoid bias, bootstrapped 95%-confidence intervals with 5000 samples instead of significance tests were calculated (as recommended e.g., by [55]). The mediation hypothesized in H5 was analyzed with the R package lavaan ([56]; version 0.6-7). A path analysis with 5000 bootstrap estimates was conducted as recommended by [57]. The mediation analysis enabled an investigation of the indirect effect of state anxiety measured in t_1 on the intention to use measured in t_3. H6 and 7 concerning group differences and the associated manipulation checks were investigated with one-way ANOVAs. When the normality assumption was violated, robust Kruskal-Wallis tests were used.

A. Trust and Intention to Use

The participants' overall mean ratings of trust, M_{t1} = 4.82 (SD_{t1} = 1.19), M_{t2} = 4.84 (SD_{t2} = 1.40), M_{t3} = 5.03 (SD_{t3} = 1.32) and of the intention to use, M_{t1} = 5.01 (SD_{t1} = 1.59), M_{t2} = 4.70 (SD_{t2} = 1.76), M_{t3} = 4.77 (SD_{t3} = 1.65) were slightly above the average (4 = *neutral*) of the 7-point Likert scales. This indicates that on average, the participants tend to trust the transport robot and rather intend to use it. In line with H1, trust and the intention to use were strongly positively correlated during all

TABLE II. CORRELATIONS OF STUDY VARBIABLES

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Affinity for technology	-													
2 Propensity to trust	**.58***	-												
3 NARS – interaction	**-.30***	**-.32***	-											
4 NARS – emotions	-.16	**-.36***	**.24***	-										
5 State anxiety t_0	-.13	**-.31***	.14	.12	-									
6 State anxiety t_1	-.13	**-.46***	.17	.14	**.72***	-								
7 State anxiety t_2	-.13	**-.36***	**.29***	.11	**.51***	**.69***	-							
8 State anxiety t_3	-.10	**-.28***	**.31***	**.22***	**.41***	**.56***	**.70***	-						
9 Trust t_1	**.34***	**.58***	**-.39***	**-.35***	-.21	**-.44***	**-.46***	**-.41***	-					
10 Trust t_2	**.47***	**.61***	**-.37***	**-.38***	-.22	**-.39***	**-.48***	**-.46***	**.75***	-				
11 Trust t_3	**.40***	**.52***	**-.42***	**-.39***	**-.29***	**-.39***	**-.42***	**-.55***	**.77***	**.84***	-			
12 Intention to use t_1	**.40***	**.47***	**-.34***	**-.30***	-.23	**-.28***	-.21	**-.32***	**.68***	**.66***	**.77***	-		
13 Intention to use t_2	**.44***	**.49***	**-.30***	**-.39***	-.19	**-.31***	**-.26***	**-.35***	**.71***	**.80***	**.79***	**.87***	-	
14 Intention to use t_3	**.44***	**.48***	**-.36***	**-.39***	-.21	**-.31***	**-.23***	**-.35***	**.70***	**.74***	**.80***	**.91***	**.93***	-

Note. * bootstrapped 95% confidence interval did not contain zero

measurements with $r = .68$ [.53; .79] in t_1, $r = .80$ [.71; .88] in t_2 and $r = .80$ [.73, .87] in t_3, supporting a positive relationship of trust with the behavioral intention (see also Table II).

B. The Role of Technology Related User Dispositions

It was hypothesized that technology-related user dispositions (affinity for technology, propensity to trust, and negative attitudes towards robots) are associated with trust (H2) and the intention to use (H3). Correlations at all points of measurements (see Table II) support positive relationships of both affinity for technology and propensity to trust with learned trust and the intention to use. Both used NARS subscales were negatively related to trust and the intention to use. All in all, these moderate to large correlations provide support for H2 and H3.

C. The Role of Hospital Patients' State Anxiety

State anxiety was hypothesized to be negatively associated with learned trust (H4.1) and the intention to use (H4.2). The correlations of Table II show that state anxiety, measured before study participants were confronted with the transport robot (t_0), was not (with the exception of state anxiety t_0 ~ trust in t_3) associated with trust and the intention to use. After the participants got familiar with the transport robot (t_1-t_3), mostly moderate, negative correlations between state anxiety and trust, as well as state anxiety and the intention to use were observed (except for intention to use t_1 ~ state anxiety t_2). All in all, these correlations provide support for H4 for state anxiety measured after participants' first contact with the transport robot.

In H5, it was expected that the effect of state anxiety on the intention to use is mediated by trust. To test this hypothesis, a mediation analysis was conducted with the included constructs

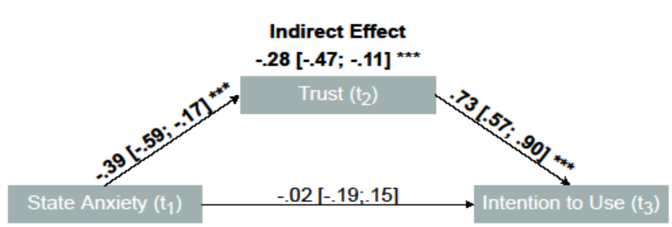

Fig. 6. Standardized direct and indirect effects of state anxiety on intention to use mediated by trust. 95 % confidence intervals are reported in brackets.
* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

measured at subsequent times of measurement (t_1: state anxiety → t_2: trust → t_3: intention to use; see Fig. 6). The confidence intervals of this indirect effect did not include zero, β = -.28 [-.47; -.11], supporting the hypothesis that trust mediates the effect of state anxiety on intention to use (H5). A non-significant direct effect of state anxiety on the intention to use supports a full mediation, β = -.02 [-.19; .15]. This indicates that trust mediates the association of state anxiety and intention to use.

D. Manipulation Checks

Manipulation checks were conducted to investigate the manipulation of predictability and controllability in video B. At t_3, perceived predictability of the robot was rated higher in conditions II ($M = 4.96$, $SD = 1.45$) and III ($M = 4.91$, $SD = 1.56$) as compared to condition I ($M = 4.18$, $SD = 1.13$), which was indicated by a significant Kruskal-Wallis test, $H(2) = 8.06$, $p = .018$, $\eta 2 = .07$. Bonferroni-corrected Dunn's tests showed that perceived predictability was significantly higher ($p = .027$) in condition II compared to condition I, but the same test for condition III compared to condition I failed to reach significance ($p = .059$). Also the changes in predictability from t_2 to t_3 were tested and again, a Kruskal-Wallis test revealed significant differences, $H(2) = 10.03$, $p = .007$, $\eta 2 = .09$. A Bonferroni-corrected Dunn's tests showed that perceived predictability significantly increased ($p = .005$) in condition II ($M = 0.99$, $SD = 1.67$) compared to condition I ($M = -0.36$, $SD = 1.30$), but the changes in condition III ($M = 0.60$, $SD = 1.68$) compared to those of condition I were not significantly different ($p = .117$). The manipulation of predictability can therefore be regarded as successful for the differences between condition I and II. However, it should be noted that these moderate effects were slightly smaller than expected in the a priori power analysis. In terms of perceived robot control, an ANOVA did not reveal significant differences in t_3 and a Kruskal-Wallis test did not reveal significant differences in the changes from t_2 to t_3. Accordingly, the manipulation of perceived robot control cannot be regarded as successful.

E. The Influence of a Predictable and Controllable Robot Behavior

In H6, it was expected that predictable robot behavior leads to lower (decreased) state anxiety, higher (increased) trust in automation, and higher (increased) intention to use compared to unpredictable robot behavior. However, Kruskal-Wallis tests revealed no significant differences in state anxiety, $H(2) = 0.87$, $p = .646$, trust, $H(2) = 0.88$, $p = .645$, and intention to use, $H(2) = 1.70$, $p = .427$ between the three experimental conditions in t_3. Moreover, no significant differences in the changes from t_2 to t_3 in state anxiety, $H(2) = 1.22$, $p = .543$, trust, $H(2) = 1.47$, $p = .480$, and intention to use, $H(2) = 3.68$, $p = .159$ were found in additional Kruskal-Wallis tests. Because of the failed manipulation check, the effects of a controllable robot behavior (H7) were not examined further. To summarize, no support for H6 or H7 was found in this study.

Since the manipulation of *actual* predictability and controllability did not lead to the expected effects, additionally the correlations of the *perceptions* of predictability and control with the outcome variables were inspected. Perceived predictability was positively correlated with trust in automation ($r_{t2} = .44$ [.23; .61], $r_{t3} = .59$ [.40; .73]) and the intention to use ($r_{t2} = .38$ [.15; .58], $r_{t3} = .58$ [.38; .72]) in t_2 and t_3. A negative association of perceived predictability and state anxiety was found in t_3 ($r_{t3} = -.41$ [-.59; -.20]), but not in t_2 ($r_{t2} = -.17$ [-.36; .03]). Furthermore, perceived robot control was positively correlated with trust in automation ($r_{t2} = .53$ [.36; .68], $r_{t3} = .53$ [.34; .68]) and intention to use ($r_{t2} = .44$ [.24; .60], $r_{t3} = .50$ [.31; .65]), and negatively correlated with state anxiety ($r_{t2} = -.28$ [-.47; -.06], $r_{t3} = -.25$ [-.46; -.02]) in t_2 and t_3.

V. Discussion

In the present online study, the role of users' dispositions, anxiety, and robot characteristics for the formation of hospital patients' trust in a transport robot was investigated. Actual patients received more and more information about the robot through descriptions, pictures, and videos. Study findings provided support for five of the seven hypotheses. Trust in a hospital transportation robot was found to be positively associated with patients' intention to use it (H1). The technology-related user dispositions, propensity to trust, affinity for technology, and negative attitudes towards robots were found to be related to learned trust (H2) and the intention to use the robot (H3). Lower state anxiety was found to be associated with higher trust and higher intention to use (H4). In line with theoretical assumptions, this relationship was essentially only found for the points of measurement of state anxiety at which participants already got to know the robot. It can be concluded that the level of anxiety in situations in which people interact with new robots for the first time affects their trust levels and their behavioral decisions regarding the robot. Central for this research and in line with this interpretation, the effect of state anxiety on intention to use was fully mediated by trust (H5). This supports the idea that the reduction of the intention to use a robot resulting from higher levels of anxiety when being introduced to a robot is at least to a considerable degree conveyed by lower trust. For both manipulated independent variables the hypotheses could not be supported. While for predictability (H6) no significant effect on the dependent variables was found, the manipulation of perceived robot control was not successful and H7 could thus not be tested in this research. However, exploratory correlation analyses supported the general idea that *perceptions* of predictability and robot control are associated with state anxiety, trust in automation, and intention to use.

A. *Theoretical Implications and Future Research*

The reported findings underline the dynamic nature of the psychological processes involved in the formation and calibration of learned trust in robots. In line with the assumptions of the Three Stages of Trust Model [15] and other trust models (e.g., [17]), it was shown that individual differences in the tendency to approach and interact with technology in general and robots in specific were associated with the psychological reaction and evaluation of unfamiliar robots. More specifically, people who have a disposition to be less explorative to interact with technology trusted the introduced robot less and indicated less likely to plan to use it. Unfavorable attitudes towards robots which the investigated patients held before the study were considerably predictive for their trust levels and usage intentions throughout the study. The correlational findings support the idea that patients tend to react very differently to unfamiliar robots based on their prior learning history. These findings essentially underline the importance of addressing individual differences in terms of technology-related attitudes and personality in research, design, and introduction of robots in the health sector.

In the study, the role of user states at the time of robot familiarization for trust formation in service robots in the health sector was supported. More specifically, it was shown that patients' experience of anxiety when getting to know a formerly unknown transport robot is essentially related to their trust in the robot. Those patients that were more anxious when first getting to know the transportation robot showed significantly less trust and intention to use the robot. Accordingly, in HRI research factors affecting the subjective experience of anxiety might be addressed more prominently in future studies.

Taken together, the findings on the role of both user dispositions and state anxiety in the process of trust formation support the importance of conceptualizing trust as a psychological phenomenon that builds on an individual learning process over time. In the process of learning to trust a newly introduced robot, users process the available information against the background of their former experience. Therefore, the inclusion of dispositional variables in HRI trust research is essential to understand how users use and interpret available information in trust formation. In terms of future research, anxiety as well as user dispositions might serve as meaningful control variables or moderators to reduce error variance. Furthermore, the presented study findings support the assumption that the formation and calibration of trust in robots is a dynamic process of learning about the robots' capabilities and functioning over time. Trust in robots in the health sector (as in all other domains) should thus not only be measured statically in one-shot designs. It is not enough to simply test a specific robot design for trustworthiness or to do simple usability tests, like trust investigations based on differences in the design. Rather, insights in trust processes in the familiarization with robots can only be understood and meaningfully investigated if the combined influences of different variable groups in a process over time are respected.

Although no effects of an *actual* predictable and controllable robot behavior were found in this study, the *perceptions* of predictability and control were in almost all cases correlated with state anxiety, trust in automation, and intention to use. This shows that perceived predictability and control are relevant constructs in HRI that might have the potential to reduce users' state anxiety as well as increase their trust and their intention to use a robot. Bringing together these findings and the considerations of Skinner [45], users' reactions to robots might not be directly affected by the *actual* robot behavior, but by the users' subjective perceptions of the robot behavior. The inconsistent findings for actual and perceived predictability as well as perceived control probably result from too weak manipulations of the independent variables, which might have resulted in smaller effect sizes than assumed in the a priori power analysis. This might be improved in future studies by enhanced realism and even increased differences in the study conditions. Furthermore, future research might aim at strengthening the experimental manipulations for predictability and controllability further - e.g., by implementing a real-life experiment. Also, it might be that the subjective perceptions of both predictability and controllability are more complex, and the chosen manipulations might somehow not reflect this complexity to a sufficient degree. Further research might address how the subjective perception of robot characteristics is build up and can be successfully manipulated in research experiments for example through robot behavior or HRI design.

B. *Strenghts and Limitations*

The reported study investigated the early phase of learning about a newly introduced transport robot in a sample of hospitalized patients. The method allowed for an investigation of a large sample size in the specific population of hospital patients, who have specific needs in terms of both physical support by technology and confidence-building in the interaction with unfamiliar technology at the same time.

Like all video-based studies, the applied study design entails several limitations in terms of stimulus realism. Since currently, the PeTRA robot is still in the concept phase of development, video-based stimuli were chosen to allow an assessment of a large sample. The resulting reduced realism of the interaction experience might also be the reason for the lack of success of the manipulations for both robot predictability and controllability. In future studies, thus, the presented findings might be further investigated in more realistic settings with robots (or robot prototypes) at higher levels of technology readiness. However, it should be noted that also simulated robot interactions can produce valid trust results that are comparable to real-life experiments (e.g. [58]). Another limitation might be a potential self-selection bias. Study participants were on average younger than the actual population of hospital patients. Moreover, more male than female patients participated. Further, it can be expected that the participants were in a better health condition than the average hospital patient. The first two points can be addressed by using quotas when recruiting participants, while the third point is ethically inevitable.

C. *Practical Implications*

Since technology development for robotics in healthcare settings is still largely in its infancy, results of studies like the one reported are valuable as they can still find their way into later products. Findings on technology-related user dispositions and state anxiety provide meaningful insights in individual processing of robot-related stimuli to be addressed in robot design and dissemination. In the process of introducing robots to patients and other human interaction partners, the individual levels and development of their state anxiety requires special consideration. For example, those experiencing higher levels of anxiety might focus more on possible risks while less anxious people might rather consider potential advantages of robots. In practice, this would imply that users with varying levels of anxiety need different information to facilitate calibrated trust and HRI. In robot design, it should be especially assessed which features of the robot might increase or decrease state anxiety. Reducing state anxiety could enable the development of calibrated trust in robots matching the actual system capabilities and allowing fact-based usage and interaction decisions.

Based on this study's correlative findings, aiming to develop robots that increase perceptions of predictability and control seems recommended for trustworthy transportation robots. It should be emphasized that so far it is unclear which robot characteristics affect these perceptions. Therefore, further research is needed on how to influence the perceptions of predictability and control positively for users. While in this study findings on robot predictability and controllability were not conclusive, future studies might aim at accumulating more evidence for their role in trust and robot adoption. This would strengthen the argument for designing predictable and/or controllable robots that e.g., provide transparent information about status changes and route progress.

The finding that patients react differently to robots based on their technology-related dispositions is especially important in the forthcoming years when robots start to be used more often in healthcare settings and users do not yet have specialized experience with robots. Not only is it important to convince care and transport personnel of the robot's usefulness, but also the patients' feelings towards robots need to be considered. In order to establish initial positive feelings, robot usage should be voluntary and associated with prior information campaigns. Taken together, introduction processes of robots in hospital settings need to be implemented holistically.

VI. Conclusion

This study investigated the role of technology-related user dispositions, state anxiety, and robot characteristics in the formation of hospital patients' trust during the familiarization with a transport robot. The results emphasize the importance of integrating technology-related user dispositions and state anxiety in both research and practical dissemination of robots in the health sector and other domains in which robots interact with humans in situations of uncertainty, lack of control, and vulnerability.

Acknowledgment

This study would not have been possible without the help of the hospital employees who in times of very strict Covid-19 restrictions helped by distributing the questionnaire among their patients and supporting them with any technical issues. The research has been conducted during the project PeTRA (16SV8357), funded by the German Federal Ministry of Education and Research.

REFERENCES

[1] M. Simon, Von der Unterbesetzung in der Krankenhauspflege zur bedarfsgerechten Personalausstattung: Eine kritische Analyse der aktuellen Reformpläne für die Personalbesetzung im Pflegedienst der Krankenhäuser und Vorstellung zweier Alternativmodelle. Düsseldorf: Working Paper Forschungsförderung, 2018. [Online]. Available: http://hdl.handle.net/10419/216021

[2] Deutscher Ethikrat, Ethikrat: Chancen für die Pflege durch verantwortliche Nutzung von Robotik. Pressemitteilung 03/2020, 2020. [Online]. Available: https://www.ethikrat.org/mitteilungen/mitteilungen/2020/ethikrat-chancen-fuer-die-pflege-durch-verantwortliche-nutzung-von-robotik/

[3] A. Khan and Y. Anwar, “Robots in healthcare: A survey,” in Advances in Intelligent Systems and Computing, Advances in Computer Vision, K. Arai and S. Kapoor, Eds., Cham: Springer International Publishing, 2020, pp. 280–292.

[4] K. Fischer, H. M. Weigelin, and L. Bodenhagen, “Increasing trust in human–robot medical interactions: Effects of transparency and adaptability,” Paladyn, Journal of Behavioral Robotics, vol. 9, no. 1, pp. 95–109, 2018, doi: 10.1515/pjbr-2018-0007.

[5] M. Sarabia, N. Young, K. Canavan, T. Edginton, Y. Demiris, and M. P. Vizcaychipi, “Assistive robotic technology to combat social isolation in acute hospital settings,” International Journal of Social Robotics, vol. 10, no. 5, pp. 607–620, 2018, doi: 10.1007/s12369-017-0421-z.

[6] A. Langer, R. Feingold-Polak, O. Mueller, P. Kellmeyer, and S. Levy-Tzedek, “Trust in socially assistive robots: Considerations for use in rehabilitation,” Neuroscience and Biobehavioral Reviews, vol. 104, pp. 231–239, 2019, doi: 10.1016/j.neubiorev.2019.07.014.

[7] Z. Aggelopoulou, N. V. Fotos, A. A. Chatziefstratiou, K. Giakoumidakis, I. Elefsiniotis, and H. Brokalaki, “The level of anxiety, depression and quality of life among patients with heart failure in Greece,” Applied Nursing Research, vol. 34, pp. 52–56, 2017, doi: 10.1016/j.apnr.2017.01.003.

[8] D. K. Moser, B. Riegel, S. McKinley, L. V. Doering, K. An, and S. Sheahan, “Impact of anxiety and perceived control on in-hospital complications after acute myocardial infarction,” Psychosomatic Medicine, vol. 69, no. 1, pp. 10–16, 2007, doi: 10.1097/01.psy.0000245868.43447.d8.

[9] M. Johnston, “Anxiety in surgical patients,” Psychological Medicine, vol. 10, no. 1, pp. 145–152, 1980, doi: 10.1017/S0033291700039684.

[10] J. Kraus, D. Scholz, E.-M. Messner, M. Messner, and M. Baumann, “Scared to trust? - Predicting trust in highly automated driving by depressiveness, negative self-evaluations and state anxiety,” Frontiers in Psychology, vol. 10, 2020, doi: 10.3389/fpsyg.2019.02917.

[11] L. Miller, J. Kraus, F. Babel, and M. Baumann, “More than a feeling: Interrelation of trust layers in human-robot interaction and the role of user dispositions and state anxiety,” Frontiers in Psychology, vol. 12, 2021, doi: 10.3389/fpsyg.2021.592711.

[12] P. A. Hancock, D. R. Billings, K. E. Schaefer, J. Y. C. Chen, E. J. de Visser, and R. Parasuraman, “A meta-analysis of factors affecting trust in human-robot interaction,” Human Factors, vol. 53, no. 5, pp. 517–527, 2011, doi: 10.1177/0018720811417254.

[13] P. A. Hancock, T. T. Kessler, A. D. Kaplan, J. C. Brill, and J. L. Szalma, “Evolving trust in robots: Specification through sequential and comparative meta-analyses,” Human Factors, 18720820922080, 2020, doi: 10.1177/0018720820922080.

[14] J. D. Lee and K. A. See, “Trust in automation: Designing for appropriate reliance,” Human Factors, vol. 46, no. 1, pp. 50–80, 2004.

[15] J. Kraus, “Psychological processes in the formation and calibration of trust in automation,” Universität Ulm, 2020.

[16] Bundesministerium für Bildung und Forschung, PeTRA: Ein Roboter-Assistent für den Personentransfer in der Pflege. [Online]. Available: https://www.interaktive-technologien.de/projekte/petra (accessed: Mar. 9 2021).

[17] K. A. Hoff and M. Bashir, “Trust in automation: Integrating empirical evidence on factors that influence trust,” Human Factors, vol. 57, no. 3, pp. 407–434, 2015, doi: 10.1177/0018720814547570.

[18] M. Lewis, K. Sycara, and P. Walker, “The role of trust in human-robot interaction,” in Foundations of Trusted Autonomy, H. A. Abbass, J. Scholz, and D. J. Reid, Eds., Cham: Springer International Publishing, 2018, pp. 135–159. [Online]. Available: https://doi.org/10.1007/978-3-319-64816-3_8

[19] E. L. Hamaker, J. R. Nesselroade, and P. C. M. Molenaar, “The integrated trait–state model,” Journal of Research in Personality, vol. 41, no. 2, pp. 295–315, 2007.

[20] S. M. Merritt and D. R. Ilgen, “Not all trust is created equal: Dispositional and history-based trust in human-automation interactions,” Human Factors, vol. 50, no. 2, pp. 194–210, 2008, doi: 10.1518/001872008X288574.

[21] T. Nomura, T. Kanda, and T. Suzuki, “Experimental investigation into influence of negative attitudes toward robots on human–robot interaction,” AI & Society, vol. 20, no. 2, pp. 138–150, 2005, doi: 10.1007/s00146-005-0012-7.

[22] T. Nomura, T. Kanda, T. Suzuki, and K. Kato, “Exploratory investigation into influence of negative attitudes toward robots on human-robot interaction,” in Mobile Robots: towards New Applications, A. Lazinica, Ed.: I-Tech Education and Publishing, 2006.

[23] F. Babel et al., “Step aside ! - VR-based evaluation of adaptive robot conflict resolution strategies for domestic service robots,” International Journal of Social Robotics, pp. 1–28, 2022.

[24] J. Kraus, D. Scholz, D. Stiegemeier, and M. Baumann, “The more you know: Trust dynamics and calibration in highly automated driving and the effects of take-overs, system malfunction, and system transparency,” Human Factors, 2019, doi: 10.1177/0018720819853686.

[25] S. M. Merritt, H. Heimbaugh, J. LaChapell, and D. Lee, “I trust it, but I don't know why: effects of implicit attitudes toward automation on trust in an automated system,” Human Factors, vol. 55, no. 3, pp. 520–534, 2013, doi: 10.1177/0018720812465081.

[26] J. Kraus, D. Scholz, and M. Baumann, “What's driving me? - Exploration and validation of a hierarchical personality model for trust in automated driving,” Human Factors, 2020, doi: 10.1177/0018720820922653.

[27] I. P. Tussyadiah, F. J. Zach, and J. Wang, “Do travelers trust intelligent service robots?,” Annals of Tourism Research, vol. 81, no. 3, p. 102886, 2020, doi: 10.1016/j.annals.2020.102886.

[28] T. Franke, C. Attig, and D. Wessel, “A personal resource for technology interaction: Development and validation of the affinity for technology interaction (ATI) scale,” International Journal of Human-Computer Interaction, vol. 35, no. 6, pp. 456–467, 2018, doi: 10.1080/10447318.2018.1456150.

[29] K. Karrer, C. Glaser, C. Clemens, and C. Bruder, “Technikaffinität erfassen - der Fragebogen TA-EG,” in Der Mensch im Mittelpunkt technischer Systeme, A. Lichtenstein, Ed., Düsseldorf: VDI Verlag GmbH, 2009, pp. 196–201.

[30] K. M. Tsui, M. Desai, H. A. Yanco, H. Cramer, and N. Kemper, “Using the "negative attitude toward robots scale" with telepresence robots,” in Proceedings of the 10th Performance Metrics for Intelligent Systems Workshop on - PerMIS '10, Baltimore, Maryland, 2010, p. 243.

[31] L. Wang, P.-L. P. Rau, V. Evers, B. K. Robinson, and P. Hinds, “When in Rome: The role of culture & context in adherence to robot recommendations,” in 2010 5th ACM/IEEE International Conference on Human-Robot Interaction (HRI), Osaka, Japan, 2010, pp. 359–366.

[32] M. M. A. de Graaf and S. Ben Allouch, “The relation between people's attitude and anxiety towards robots in human-robot interaction,” in 2013 IEEE RO-MAN, Gyeongju, 2013, pp. 632–637.

[33] C. D. Spielberger, “Theory and research on anxiety,” in Anxiety & Behavior, C. D. Spielberger, Ed., New York, London: Academic Press, 1966.

[34] N. Schwarz and G. Clore, “How do I feel about it? Informative functions of affective states,” in Affect, Cognition, and Social Behavior, K. Fiedler and J. P. Forgas, Eds.: Hogrefe, 1988, pp. 44–62.

[35] J. P. Forgas and R. East, “On being happy and gullible: Mood effects on skepticism and the detection of deception,” Journal of Experimental Social Psychology, vol. 44, no. 5, pp. 1362–1367, 2008, doi: 10.1016/j.jesp.2008.04.010.

[36] A. P. Brief and H. M. Weiss, “Organizational behavior: Affect in the workplace,” Annual Review of Psychology, vol. 53, no. 1, pp. 279–307, 2002.

[37] G. R. Jones and J. M. George, “The experience and evolution of trust: Implications for cooperation and teamwork,” The Academy of Management Review, vol. 23, no. 3, pp. 531–546, 1998, doi: 10.5465/amr.1998.926625.

[38] J. R. Dunn and M. E. Schweitzer, “Feeling and believing: The influence of emotion on trust,” Journal of Personality and Social Psychology, vol. 88, no. 5, pp. 736–748, 2005, doi: 10.1037/0022-3514.88.5.736.

[39] N. Bender, S. E. Faramawy, J. Kraus, and M. Baumann, “The role of successful human-robot interaction on trust: Findings of an experiment with an autonomous cooperative robot,” in Proceedings of ACM/IEEE International Conference on Human-Robot-Interaction (HRI’21), New York, NY, USA: ACM, 2021.

[40] J. M. Burger and R. M. Arkin, “Prediction, control, and learned helplessness,” Journal of Personality and Social Psychology, vol. 38, no. 3, p. 482, 1980.

[41] M. J. Zvolensky, C. W. Lejuez, and G. H. Eifert, “Prediction and control: Operational definitions for the experimental analysis of anxiety,” Behaviour Research and Therapy, vol. 38, no. 7, pp. 653–663, 2000.

[42] S. F. Maier and M. E. Seligman, “Learned helplessness: Theory and evidence,” Journal of Experimental Psychology: General, vol. 105, no. 1, pp. 3–46, 1976.

[43] E. Stotland and A. L. Blumenthal, “The reduction of anxiety as a results of the expectation of making a choice,” Canadian Journal of Psychology, vol. 18, pp. 139–145, 1964, doi: 10.1037/h0083492.

[44] C. Grillon, J. P. Baas, S. Lissek, K. Smith, and J. Milstein, “Anxious responses to predictable and unpredictable aversive events,” Behavioral Neuroscience, vol. 118, no. 5, pp. 916–924, 2004, doi: 10.1037/0735-7044.118.5.916.

[45] E. A. Skinner, “A guide to constructs of control,” Journal of Personality and Social Psychology, vol. 71, no. 3, pp. 549–570, 1996, doi: 10.1037/0022-3514.71.3.549.

[46] J. Koo, D. Shin, M. Steinert, and L. Leifer, “Understanding driver responses to voice alerts of autonomous car operations,” International Journal of Vehicle Design, vol. 70, no. 4, p. 377, 2016, doi: 10.1504/IJVD.2016.076740.

[47] N. Du et al., “Look who’s talking now: Implications of AV’s explanations on driver’s trust, AV preference, anxiety and mental workload,” Transportation Research Part C: Emerging Technologies, vol. 104, pp. 428–442, 2019, doi: 10.1016/j.trc.2019.05.025.

[48] E. Broadbent, R. Stafford, and B. A. MacDonald, “Acceptance of healthcare robots for the older population: Review and future directions,” International Journal of Social Robotics, vol. 1, no. 4, pp. 319–330, 2009, doi: 10.1007/s12369-009-0030-6.

[49] S. Zafari and S. T. Koeszegi, “Attitudes toward attributed agency: Role of perceived control,” International Journal of Social Robotics, 2020, doi: 10.1007/s12369-020-00672-7.

[50] F. Faul, E. Erdfelder, A.-G. Lang, and A. Buchner, “G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences,” Behavior Research Methods, no. 39, pp. 175–191, 2007.

[51] R. Greszki, M. Meyer, and H. Schoen, “The impact of speeding on data quality in nonprobability and freshly recruited probability-based online panels,” in Online Panel Research, M. Callegaro, R. Baker, J. Bethlehem, A. S. Göritz, J. A. Krosnick, and P. J. Lavrakas, Eds., Chichester, UK: John Wiley & Sons, Ltd, 2014, pp. 238–262.

[52] Blender Online Community, Blender - a 3D modelling and rendering package. Stichting Blender Foundation, Amsterdam, 2018. [Online]. Available: http://www.blender.org/

[53] Questback GmbH, EFS Survey. Köln: Questback GmbH, 2020.

[54] A. Field, J. Miles, and Z. Field, Discovering Statistics Using R. Los Angeles, London, New Delhi, Singapore, Washington, DC: SAGE Publications, 2012.

[55] M. Wood, “Bootstrapped confidence intervals as an approach to statistical inference,” Organizational Research Methods, vol. 8, no. 4, pp. 454–470, 2005, doi: 10.1177/1094428105280059.

[56] Y. Rosseel et al., “lavaan: An R package for structural equation modeling,” Journal of Statistical Software, vol. 48, no. 2, p. 2012, 2012. [Online]. Available: http://www.jstatsoft.org/v48/i02/

[57] A. F. Hayes, Introduction to Mediation, Moderation, and Conditional Process Analysis: A regression-based approach, 2nd ed. New York, London: The Guilford Press, 2018.

[58] F. Babel, J. Kraus, P. Hock, H. Asenbauer, and M. Baumann, “Investigating the validity of online robot evaluations: Comparison of findings from an one-sample online and laboratory study,” in Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction, Boulder, CO, USA: Association for Computing Machinery, 2021, pp. 116–120.

[59] K. Karrer, C. Glaser, C. Clemens, and C. Bruder, “Technikaffinität erfassen - der Fragebogen TA-EG,” in Der Mensch im Mittelpunkt technischer Systeme, A. Lichtenstein, Ed., Düsseldorf: VDI Verlag GmbH, 2009, pp. 196–201.

[60] C. Englert, A. Bertrams, and O. Dickhäuser, “Entwicklung der Fünf-Item-Kurzskala STAI-SKD zur Messung von Zustandsangst,” Zeitschrift für Gesundheitspsychologie, vol. 19, pp. 173–180, 2011, doi: 10.1026/0943-8149/a000049.

[61] F. D. Davis, “Perceived usefulness, perceived ease of use, and user acceptance of information technology,” MIS Quarterly, vol. 13, no. 3, pp. 319–340, 1989. Available: http://www.jstor.org/stable/249008

[62] L. I. Pearlin and C. Schooler, “The structure of coping,” Journal of Health and Social Behavior, vol. 19, no. 1, pp. 2–21, 1978.