Differing Care Giver and Care Receiver Perceptions of Robot Agency in an In-Home Socially Assistive Robot for Exercise Engagement

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***Abstract*— We present the results of an online, video-based experimental study investigating the impact of robot agency on perceptions of a socially assistive robot (SAR) shown supporting in-home care. We consider two key participant groups: care *givers* and care *receivers*. We did not find significant results regarding the impact of agency on overall participant perceptions of the SAR, but we did identify some differences in what these two participant groups might perceive as being best for themselves versus each other. Firstly, care givers perceived more potential benefit from the robot than care receivers did, challenging possible assumptions about who is set to gain most from deployment of these systems. Secondly, care receivers generally perceived the lower agency robot as being more beneficial for themselves, even as they ascribed the higher agency robot more potential to benefit care receivers.**

I. Introduction

Previous work has demonstrated the potential to use SARs as motivational aids in increasing engagement with therapeutic and/or rehabilitative exercise programs [1]–[3], and investigated different robot design factors in this context (e.g. [4]–[8]). In this work, we investigate the impact of manipulating SAR *agency*, by which we generally mean the SAR's capacity to autonomously "get on with things" (c.f. the capacity for self-control in Gray et al.'s definition of agency in the context of mind perception [9]). We specifically examine potential impact on participants' perception of SAR potential benefit, acceptability, Intention to Use (ITU) and how it might impact on users' Basic Psychological Needs (BPN). We identify BPN as a particularly salient measure for examining SAR impact because BPN satisfaction is associated with wellbeing and motivation, outcomes also generally targeted by SARs (e.g. [2]–[4], [6], [10]). Recent work indicates the potential for agency manipulations to influence perceived impact of an assistive, artificial social agent on user BPN in a banking context [11], so we look to see whether such effects might also emerge in a health-related context.

Previous work on perceptions of robot agency indicates that perceived control over an interaction influences the extent to which high robot agency might evoke negative attitudes towards the robot [12]. Studies of the care giver-care receiver diad highlight complex power and control dynamics, suggesting differences in how much care givers versus care receivers might feel in control of their care-related interactions [13]–[15]. We might hence expect care givers and care receivers to feel differently about introduction of a SAR and/or its level of agency. With this work, we examine whether any impacts of robot agency vary across two key participant groups: participants who self-identify as having a long-term health condition/disability (henceforth referred to as *care receivers*) and participants who have informal/unpaid caring responsibilities (henceforth referred to as *care givers*). Our overarching research question is then: **how does high versus low robot agency influence perceptions of an in-home SAR, and does this vary across care givers versus care receivers?**

II. Related Work

A. Potential Impacts of Robot Agency

To our knowledge, no previous work has investigated the impacts of manipulating robot agency in SAR-supported exercise.We identified one previous work specifically on the topic of SAR agency: Short et al. found that variations in morphological and behavioural agency differently affected groups of children with autism according to the kinds of interaction those children engaged in [16]. On agency more broadly, recent work by Zafari and Koeszegi identifies user perceived control as a moderating factor that can influence the impact(s) of robot agency – they found a correlation between ascription of robot agency and negative attitude towards that robot, for users who felt low control over a collaborative human-robot interaction [12].

B. SARs for Care Givers and Care Receivers

The majority of works on SARs seemingly consider the impacts of robot design choices on care receivers, those typically identified as a SAR's "primary user". Within health-care research, it is recognised that care givers and care receivers might have differing needs (e.g. [17], [18]), including specifically with regards to their BPN satisfaction [19]. We hence identify the importance of considering care giver BPN, alongside care receiver BPN, as well as our other measures of interest, when evaluating SAR design and deployment. Some previous works on SARs as therapeutic aids have approached SAR design from an 'aid to/tool for care giver' approach over trying to design and develop (directly) with/for care receivers (e.g. [10], [20]). Other attempts to consider multiple

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user groups have generally taken the form of ethnographic studies (examining the impacts of robot deployment and observing multi user-robot interactions in-the-wild, e.g. [21]) and/or participatory design studies. Few previous quantitative experimental HRI works seem to consider these different perspectives, with participants typically experiencing and evaluating interactions with the robot from the care receiver perspective only.

III. Materials and Methods

We designed a between-subject, video-based survey study designed to investigate the impact of robot agency on care giver/receiver perceptions of an in-home socially assistive robot. Study design, experimental protocol and data collection was conducted in line with local (Austrian) ethics regulations and guidelines.

A. Participants

Prolific's participant screening tools were utilised to recruit 200 participants, representing approximately even numbers of care givers versus care receivers. Participants who successfully completed one or more of the two attention checks were compensated £8.27/hour via the Prolific platform (no participants failed the attention checks). 26 participants had to be removed from the sample as the data file indicated that they had not watched the complete video vignette (19 men and 7 women). The final sample consisted of 174 participants (89 women, 82 men, 3 non-binary participants with age range 18 - 75). The mean age of the care givers was 31, and the mean age of care receivers was 42 such that there was a significant difference in age between the two groups ($t(167.863)=5.53$, $p < .001$).

B. Scenario Narrative and Video Clip Creation

Our video scenario depicted Softbank's Pepper robot[1] deployed within the home of a user and interacting, separately, with that user as well as their informal carer. The initial study information sheet introduced Pepper as *"a robot that can be used at home to support people who need to exercise e.g. to help manage a long term health condition or disability, or to aid recovery from an injury"*.

The scenario narrative was specifically designed to showcase how the robot might be deployed in a situation involving both formal and informal care, showcasing robot-care giver/receiver interactions (Figure 1 top and bottom respectively). These interactions further referenced the care receiver's therapist as being the (known) healthcare professional who had actually prescribed the care receiver's exercises. The depicted role of the robot within this care receiver, formal and informal care giver triad was designed with reference to expert-informed design guidelines for socially assistive robots in therapy [10]. A selection of example comparisons are provided in Table II. Male and female voiced versions of the high and low agency robot video conditions are available online[2].

[1]https://www.aldebaran.com/en/pepper
[2]https://kwinkle.github.io/lauracollab.html

Scene set-up was designed to resemble previous work using video stimuli to investigate perception of in home care robots [8], utilising some of the same exemplar exercises (neck tilts and stretches taken from publicly available Arthritis Research advice materials [3]). Camera placement was such that the actors' faces were never seen. Further, only one video was used to create all eventual stimuli by overlaying the (manipulated) robot audio such that videos were identical in every other regard.

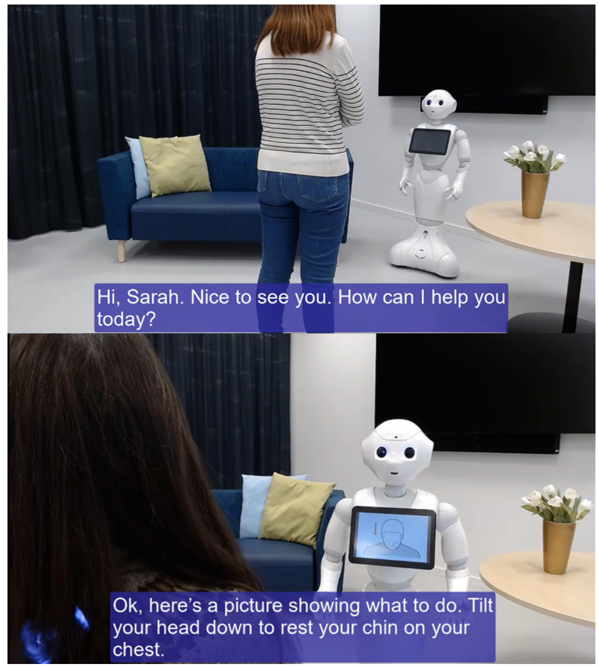

Fig. 1. Video set-up for the two different scenes depicted in the video. Pepper first interacts with the care giver, before the video cuts to Pepper talking to the care receiver and encouraging her through exercises set by her therapist.

Both actors were women on the research team (referred to with fictitious female names) and the user's therapist (unseen in the videos) was also referred to as *she*. For the robot, we elected to use a male voice for Pepper [4] for two key reasons. Firstly, previous work has indicated interaction effects between agency and participant gender in perceptions of (specifically) female gendered agents [11], which we might expect hence to influence our results. Secondly, in a related study (currently under review) we found no evidence that male gendering of a SAR for in-home care, when seen interacting with women users, influenced how men or women observers perceived its effectiveness. We recognise our gendering of the fictitious robot users might have resulted in it being easier for women participants to imagine themselves in the actors position than men, but prefer this to the risk of inducing additional interaction effects relating to gendered expectations known to influence how differently gendered robots should interact with differently gendered users [22].

[3]https://www.versusarthritis.org/
[4]The "Joey" option for Amazon's synthetic voice "Polly" generated via online platform ttsmp3.com.

C. Experimental Conditions

We manipulated robot agency in two ways. Firstly, we altered how we described the robot's function within the briefing information presented to participants ahead of experimental measure completion. These briefings were also tailored to each participant group; both adaptations can be seen in Table I. Secondly, we manipulated the way in which the robot appeared to interact with its users. Where the high agency robot *gave instructions* or *stated* what it was going to do, the low agency robot instead *asked* what it should/could do. Examples of these dialogue-based manipulations of agency are provided in Table II. These manipulations are based on previous work which examined the impact of high versus low agency on perceptions on a digital (voice only) AI banking assistant [11]. Following the participant exclusions described under Section II-A we ultimately analysed data for 90 care receivers (45 per condition) and 84 care givers (46 in the high agency condition and 38 in the low agency condition).

D. Experimental Measures

Below we present all experimental measures in the same order in which they were shown to participants immediately after watching the video stimulus.

1) Manipulation Check: In order to confirm our manipulation of robot agency, we asked participants to indicate how much they agreed with the statement *the robot decides what to do by itself* on a five-point scale from *not at all* to *very much*.

2) Perceived Benefit of the Robot: Participants were asked to indicate the extent to which they thought the robot would be able to benefit them as care givers or receivers respectively per Table III.

3) Basic Psychological Need Satisfaction: The Basic Psychological Needs items (see Table III are based on the Basic Psychological Needs Scale for Technology Use [23] that was developed based on the original scales (e.g., [24]–[26]) but adapted for technology interaction contexts. Relatedness was split into Relatedness to Others and Relatedness to the Robot, assessed with three items each. Care givers and care receivers were instructed to imagine using the robot for help with their caretaking/for their exercise respectively.

4) Intention to Use: We utilised two ITU items based on the ITU items from the Technology Acceptance Model (TAM3, [27]).

5) Acceptability: We adapted a set of questions concerning the use of socially assistive robots for therapy as previously used in HRI research [28], originally based on the Unified Theory of Acceptance and Use of Technology [29]. Note that we identify two sets of acceptability questions: acceptability to self and acceptability to other, the latter asking care givers/receivers about the potential acceptability/benefit of the robot they care for/who care for them respectively (see items [U3] and [U5] in Table III).

E. Study Procedure

Prior to taking part in the study, all participants were instructed to either use headphones or keep their computer/laptop audio on high volume for the duration of the study. First, participants read an introduction, confirmed their consent and filled out basic demographic information. Once these initial steps were completed, a short instruction appeared, which was followed by the video. One of the two video conditions (high/low agency robot) was randomly assigned to each participant. After the video, participants were asked to rate whether they understood the robot and about their prior experience with robots and Pepper in particular. Subsequently, participants answered questions as per the experimental measures presented previously. Finally, participants were shown a debrief page before being redirected to Prolific's platform to process their financial compensation. The study took between 8-9 minutes on average.

IV. Results

A. Manipulation Check

An independent-samples t-test confirms a significant difference in the agency rating of Pepper between participants who saw the low agency (M = 2.31, SD = 1.14) versus the high agency (M = 1.99, SD = .96) video condition (t(172) = 2.01, p = .046). Therefore, we can confirm that our agency manipulation was successful.

B. Perceived Benefit

Given the very different roles care givers and care receivers play within the care interaction, we first check for overall differences their perceived benefit from the robot, regardless of robot agency manipulation, using an Mann-Whitney U test. The group differences were determined significant ($U = 3060, p = .023$) with care givers perceiving significantly higher benefit from the robot in comparison to care receivers.

To check for group differences across both participant group and robot agency, we conducted a Kruskal-Wallis test. The Kruskal-Wallis test just failed to reach significant differences between the groups ($H(3) = 7.62, p = .055$). Figure 2 shows the higher perceived benefit of care givers noted above, as well as an indication that, whilst it did not reach significance, care givers and receivers were particularly differing in perceived benefit of the *low agency* robot.

C. Basic Psychological Need (BPN) Satisfaction

All BPN measures were checked for consistency and shown to be reliable via Cronbach's alpha with results as follows: Autonomy α = .88; Competence α = .93; Relatedness to Others α = .83; Relatedness to Technology α = .88. Based on these good construct reliability scores, we conducted four Kruskal-Wallis tests to compare the BPN satisfaction between the four groups. There was no significant difference in BPN satisfaction scores across groups (Autonomy: H(3) = .60, p = .897; Competence: H(3) = .39, p = .942; Relatedness to Others H(3) = 2.79, p = .426; Relatedness to Technology H(3) = 2.17, p = .538).

TABLE I

ROBOT AGENCY MANIPULATIONS WITHIN TAILORED STUDY MOTIVATION AS PRESENTED TO EACH PARTICIPANT GROUP.

Participant Group	**Robot Agency**	**Pre-Measures Briefing (as Adapted Across Participant Groups and Robot Agency)**
Care Receivers	(intro. text)	We want to understand if/how this robot would be useful for people with long-term health conditions. When answering the following questions, try to imagine yourself in Lisa's position: you see a therapist once per week but have to do exercise practice every day in-between those meetings. You have been prescribed the robot to help with this.
	High Agency	The robot can take the lead and supervise you in doing the daily exercises
	Low Agency	Based on requests from yourself and your caregivers, the robot can support you in doing the daily exercises.
Care Givers	(intro. text)	We want to understand if/how this robot would be useful for people with caring responsibilities. When answering the following questions, try to imagine yourself in Sarah's position: a close friend or family member that you care for has a health condition for which they see a therapist once per week. They are supposed to do extra exercise practice everyday in between those meetings and have been prescribed the robot to help with this.
	High Agency	The robot is able to take the lead in supporting the person you take care of.
	Low Agency	Based on requests from yourself and the person you care for, the robot can assist you in supporting the person you care for.

TABLE II

EXAMPLES OF THE MANIPULATED ROBOT DIALOGUE ACROSS CONDITIONS.

Scene 1: Pepper interacting with Sarah, the (informal) care giver	
Low Agency Examples	*High Agency Examples*
Yes I got the exercises and will ask Lisa if she wants to do them when she is ready. Would you like me to send out a message to you once we have completed the exercises for today?	Yes I got the exercises and will ensure that Lisa does them when she gets here. As always, I will send out a message to you once we have completed the exercises for today.
Sure, is there anything else you would like me to do?	Sure, I will also enter her progress into your training plan.
Scene 2: Pepper interacting with Lisa, the care recipient	
Low Agency Examples	*High Agency Examples*
Would you like to start with today's exercises?	Let's get started with today's exercises!
Which exercise shall we start with? We have to do some neck tilts and neck stretches.	We have to do some neck tilts and neck stretches. Let's start with the neck tilts.
It is ok to be tired, as long as the exercises aren't causing any pain. Do you think you could give the neck stretches a go?	It is ok to be tired, as long as the exercises aren't causing any pain. Let's give the neck stretches a go.
I would like to inform Sarah and the therapist that you have completed the exercises and share your progress with them. Is this okay for you?	I will inform Sarah and the therapist that you have completed the exercises and share your progress with them.

TABLE III

EXPERIMENTAL MEASURES, ALL OF WHICH UTILISED FIVE-POINT LIKERT SCALES E.G. FROM *not at all* TO *very much*.

Measure	**Participants**	**[Item] Wording as Presented to Participants**
Manipulation Check	All	The robot decides what to do by itself.
Perceived Benefit	Care Receivers	Do you think you would benefit from using this robot for daily exercises?
	Care Givers	Do you think you would benefit from using this robot to help with your caretaking responsibilities?
BPN: Autonomy	All	When I use the robot, I can act independently. When I use the robot, I feel like I am in control. When I use the robot, I feel like I can perform actions in the way I want to.
BPN: Competence	All	When I use the robot, I feel competent. When I use the robot, I feel empowered in my own abilities. When I use the robot, I feel confident that I can reach my goals.
BPN: Relatedness to Others	All	When I use the robot, I feel less alone. When I use the robot, I feel like my social circle reacts positively to my use of the robot. When I use the robot, I feel like I look good in front of my social circle.
BPN: Relatedness to Robot	All	I can imagine building a bond with the robot. I have a friendly feeling towards the robot. When I use the robot, I feel like the interaction goes both ways.
Intention to Use (ITU)	All	I could imagine to use the robot in the future. I would like to inform myself about products that are similar to this robot
Acceptability (Self)	All	[U1] I feel apprehensive about the use of social robots for in-home healthcare. [U2] Social robots are somewhat intimidating to me. [U4] I think using social robots for in-home healthcare is a good idea. [U6] A social robot would be useful in supporting in-home healthcare.
Acceptability (Other)	Care Receivers	[U3] I think social robots might be intimidating to the person(s) who care for me. [U5] I think social robots would make in-home care better for the person(s) who care for me.
	Care Givers	[U3] I think social robots might be somewhat intimidating to the person(s) I care for. [U5] I think using social robots would make inhome healthcare better for the person(s) I care for.

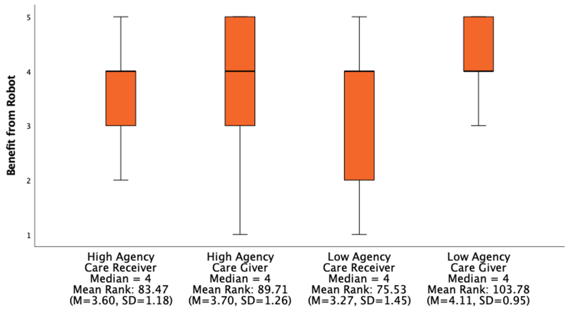

Fig. 2. Perceived benefit of robot across groups.

A Spearman's correlation between BPN and Intention to Use (ITU) confirmed positive correlations between Autonomy Satisfaction and ITU (rs = .347, p $<$ .001); Competence Satisfaction and ITU (rs = .692, p $<$ .001); Relatedness to Others Satisfaction and ITU (rs = .661, p $<$ .001) as well as Relatedness to Technology Satisfaction and ITU (rs = .653, p $<$ .001).

D. Intention to Use (ITU)

A Kruskal-Wallis test revealed no significant difference our four robot agency-participant groupings: $H(3) = 4.64, p = .200$.

E. Acceptability (Self)

As shown in Table III, we split our acceptability items into two sub-scales. Acceptability (Self), contains items [U1, U2, U4, U6] referring to participants own acceptability of the robot. These items yielded acceptable Cronbach's alpha scores ($\alpha = .75$) such that we combined them into a single measure for analysis via a Kruskal-Wallis test to compare for group differences. The results of the test were not significant (H(3) = 1.98, p = .577).

F. Acceptability (Other)

Acceptability (Other) contains items [U3, U5] asking care givers and receivers to assess Acceptability (Other) [U3, U5] items did not reach strong enough reliability scores to be combined ($\alpha = .41$).

We conducted a Kruskal-Wallis test to compare group differences for [U3]. The analysis revealed significant differences between the groups: H(3) = 8.68, p = .034. The mean rank score of 97.91 for the care receivers in the high agency condition, a mean rank score of 73.47 for the care givers in the high agency condition, a mean rank score of 97.90 for the care receivers in the low agency condition and a mean rank score of 79.84 for the care givers in the low agency condition. The table below (Table IV) also shows the mean values for better interpretation.

For [U5], given that we also found overall participant group differences in perceived benefit (regardless of robot condition) we first checked for equivalent differences in [U5]: participants' perceived benefit to their care giver/receiver(s). A Mann-Whitney U test failed to reach significance (U = 3332.5, p = .161). Looking at the mean values across groups (Table V) we can see that care givers generally perceived higher potential benefit to care receivers, than care receivers perceived benefit to care givers (M = 3.50, SD = 1.31), and again (somewhat mirroring the results on perceived benefit to self) that care receivers are particularly unconvinced of potential benefit from the low agency robot.

TABLE IV

CARE GIVERS/RECEIVERS PERCEIVED INTIMIDATION OF THE ROBOT FOR THEIR CARE RECEIVERS/GIVERS ACROSS GROUPS (MEASURE [U3])

Group	Mean	SD
Care Receivers (on Givers) High Agency	2.51	1.22
Care Receivers (on Givers) Low Agency	2.51	1.14
Care Givers (on Receivers) High Agency	3.17	1.40
Care Givers (on Receivers) Low Agency	3.00	1.34

TABLE V

CARE GIVERS/RECEIVERS PERCEIVED BENEFIT OF ROBOT TO THEIR CARE RECEIVERS/GIVERS ACROSS GROUPS (MEASURE [U5])

Group	Mean	SD
Care Receivers (on Givers) High Agency	3.67	1.13
Care Receivers (on Givers) Low Agency	3.33	1.46
Care Givers (on Receivers) High Agency	3.85	1.05
Care Givers (on Receivers) Low Agency	3.79	1.02

To check for group differences across both participant group and robot agency, we conducted a Kruskal-Wallis test. The Kruskal-Wallis test determined no significant differences between the groups (H(3) = 2.69, p = .442).

V. DISCUSSION

A. Overall Perceptions of the In-Home SAR

We identify our measures of perceived BPN satisfaction as being one proxy for the robot's potential to support and/or increase engagement with in-home exercise. We found no evidence of robot agency impacting perceptions of BPN satisfaction, regardless of participant group. In general, the BPN satisfaction was relatively high for all groups (means across all BPN $>$ 3.00) which suggests participants do perceive positive BPN satisfaction relating to deployment of a SAR like that in the video. We were particularly interested in BPN satisfaction as previous work [11] has shown that agent agency (in combination with agent gender) can have significant impact on users' perceived BPN satisfaction in a banking context. However, the current findings suggest that agency alone is not an impact factor for users' BPN satisfaction in the context of SAR rehabilitation, at least for the male gender-cued robot we utilised in our video stimuli. We use our measures of ITU, Acceptability (Self) and Acceptability (Other) to comment on acceptability; finding no evidence of robot agency or participant group influencing these measures. From these results, there seems no strong reason to engage (or not) a particular level of SAR agency. We did however find some evidence of difference in perceived benefit to self across participant groups. In particular, it is interesting, and perhaps somewhat surprising, that **care givers generally**

perceive greater potential benefit from robot deployment than care receivers do, as many SAR works typically assume and/or frame care receivers as being the primary user/beneficiary of robot deployment.

B. What Level of Robot Agency, For Who?

We found evidence of differences in perceived benefit to self across participant groups, with pairwise comparisons indicating this being strongest (but just failing to reach significance) in the low agency robot condition. In particular, **there seems to be a mismatch in care giver and care receiver perceptions of the low agency robot**. Of the two robot conditions, care receivers ascribed greater potential benefit to the high agency robot, whereas care givers ascribed greater potential to the low agency robot.

On the former, care receivers assessment of the robot's potential benefit likely correlates with their overall belief that exercises can in fact improve their health, or the extent to which daily exercise is really a priority for them. Care givers on the other hand typically have many other responsibilities alongside care giving, and may hence see significant potential benefit in a system that can help them and the person they care for to keep track of and manage daily exercises prescribed by the therapist – something that often currently falls to e.g. spouses or close family members [10].

On the latter, **care givers rated the low agency SAR as most beneficial for themselves, but simultaneously rated the high agency robot as more benefiting for care receivers** (experimental measure [U5]). Whilst benefit to other did not vary significantly between groups, this mismatch between what care givers rated best for themselves versus for care givers is interesting; especially as care receivers did indeed perceive the high agency robot as having most potential benefit to them. This mismatch likely indicates potential differences and complexities in participants' subject positioning of themselves and their care giver/receiver within the care relationship, and how hence they might imagine a triadic care relationship including the SAR could/should "look like".

For care receivers, we might speculate that the higher agency robot is perceived as having greater potential to support both themselves and the care giver in 'getting things done' than the lower agency robot, which requires more direction and affirmation/agreement from both care givers and receivers. This may reflect conceptualisations of their care as a "burden" on the close friends and family typically providing this informal care and other support [13] [14]. They might also see increased potential for the (more authoritative) high agency robot to keep them engaged in their exercise sessions, preventing them from giving up too easily [10].

Care givers also perceived the high agency robot as having most potential benefit for care receivers, but why then might they simultaneously perceive the low agency robot as having more potential beneficial to themselves? One interpretation of these findings would be that care givers might feel more *threatened* by the high agency robot. However, the lack of significant differences on the *BPN: Autonomy* measure suggests this isn't the case. It could be instead that care givers struggle to trust or believe a social robot could in fact 'take the lead' in their caring responsibilities, caring being a very *human* act in which they take pride, to which the high agency robot offer. Alternatively, given one framing of (informal) caregiving as a familial obligation [14] it could also be that they are reluctant to "cede control" or "shirk their responsibility". We must also be cognisant of the **age difference between our care giver and care receiver population groups** – our care giver participants were significantly younger then our care receiver participants. Whilst previous work has found minimal evidence of user age impacting user acceptance of healthcare robots [30], age could be a mediating factor in e.g. the "responsibility" versus "burden" narratives we have previously outlined. Again, more study is required and we identify a need for future work to thoroughly and specifically consider the ways in which SARs could/should interact with care givers in the context of delivering in-home care.

Together, our results raises interesting questions about if/how SAR agency should vary between care givers and care receivers. Whilst additional qualitative study is required to further unpick the mechanisms underpinning our results, our results would initially suggest that **SARs could take higher levels of agency during interactions with the care receiver and lower levels of agency during interactions with the care giver – however we suggest this must be carefully considered in the context of potential power (im)balances between care givers/receivers** [31]. Specifically, we must ensure that care receivers ultimately remain 'in control' of their care activities and are able to opt in/out as they wish, and that we do not reinforce (often misunderstood) notions of informal care as an "obligatory burden" that care receivers feel bad about/care givers wish to be rid of. Further, in the broader context of health service provision, that higher agency robots (potentially requiring less human care giver input) do not serve to motivate/justify reduced human-human interactions within care.

VI. Conclusion

We have conducted a novel experimental study investigating the (differing) impacts of robot agency on care giver and care receiver perceptions of a SAR. Overall, we did not see strong results regarding the impact of agency on overall perception of a SAR, particularly with respect to BPN satisfaction, which we identify as a particularly salient measure pertinent to SAR deployment. However, by examining for potential differences between care givers and care receivers, we did identify some potential tensions in what these different user groups might want and/or assess the robot for themselves versus each other. We suggest, broadly, that care giver versus care receiver perspectives require increased consideration in more quantitative works on perception of SARs (like ours), and that robot agency specifically is worthy of additional, qualitative study considering both care giver and care receiver perspectives.

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REFERENCES

[1] J. S. Lara, J. Casas, A. Aguirre, M. Munera, M. Rincon-Roncancio, B. Irfan, E. Senft, T. Belpaeme, and C. A. Cifuentes, "Human-robot sensor interface for cardiac rehabilitation," in *2017 International Conference on Rehabilitation Robotics (ICORR)*, Jul. 2017, pp. 1013–1018.

[2] J. Fasola and M. J. Matarić, "Robot exercise instructor: a socially assistive robot system to monitor and encourage physical exercise for the elderly," in *RO-MAN, 2010 IEEE*. IEEE, 2010, pp. 416–421.

[3] N. T. Fitter, M. Mohan, K. J. Kuchenbecker, and M. J. Johnson, "Exercising with Baxter: preliminary support for assistive social-physical human-robot interaction," *Journal of NeuroEngineering and Rehabilitation*, vol. 17, no. 1, p. 19, Feb. 2020. [Online]. Available: https://doi.org/10.1186/s12984-020-0642-5

[4] L. Sussenbach, N. Riether, S. Schneider, I. Berger, F. Kummert, I. Lutkebohle, and K. Pitsch, "A robot as fitness companion: Towards an interactive action-based motivation model," in *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, Aug. 2014, pp. 286–293.

[5] D. J. Rea, S. Schneider, and T. Kanda, ""Is this all you can do? Harder!": The Effects of (Im)Polite Robot Encouragement on Exercise Effort," in *Proceedings of the 2021 ACM/IEEE International Conference on Human-Robot Interaction*, ser. HRI '21. New York, NY, USA: Association for Computing Machinery, Mar. 2021, pp. 225–233. [Online]. Available: http://doi.org/10.1145/3434073.3444660

[6] K. Swift-Spong, E. Short, E. Wade, and M. J. Mataric, "Effects of comparative feedback from a Socially Assistive Robot on self-efficacy in post-stroke rehabilitation," pp. 764–769, 2015.

[7] A. Tapus, C. Ţăpuş, and M. J. Matarić, "User-robot personality matching and assistive robot behavior adaptation for post-stroke rehabilitation therapy," *Intelligent Service Robotics*, vol. 1, no. 2, pp. 169–183, 2008.

[8] K. Winkle, P. Caleb-Solly, U. Leonards, A. Turton, and P. Bremner, "Assessing and Addressing Ethical Risk from Anthropomorphism and Deception in Socially Assistive Robots," in *2021 16th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, Mar. 2021.

[9] H. M. Gray, K. Gray, and D. M. Wegner, "Dimensions of mind perception," *Science*, vol. 315, no. 5812, pp. 619–619, 2007, place: US Publisher: American Assn for the Advancement of Science.

[10] K. Winkle, P. Caleb-Solly, A. Turton, and P. Bremner, "Social Robots for Engagement in Rehabilitative Therapies: Design Implications from a Study with Therapists," in *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, ser. HRI '18. New York, NY, USA: ACM, 2018, pp. 289–297. [Online]. Available: http://doi.acm.org/10.1145/3171221.3171273

[11] L. Moradbakhti, S. Schreibelmayr, and M. Mara, "Do Men Have No Need for "Feminist" Artificial Intelligence? Agentic and Gendered Voice Assistants in the Light of Basic Psychological Needs," *Frontiers in Psychology*, vol. 13, 2022. [Online]. Available: https://www.frontiersin.org/article/10.3389/fpsyg.2022.855091

[12] S. Zafari and S. T. Koeszegi, "Attitudes Toward Attributed Agency: Role of Perceived Control," *International Journal of Social Robotics*, vol. 13, no. 8, pp. 2071–2080, Dec. 2021. [Online]. Available: https://doi.org/10.1007/s12369-020-00672-7

[13] C. L. Kemp, M. M. Ball, and M. M. Perkins, "Convoys of care: Theorizing intersections of formal and informal care," *Journal of Aging Studies*, vol. 27, no. 1, pp. 15–29, Jan. 2013. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0890406512000746

[14] J. Finch, P. J. V. Finch, and J. Mason, *Negotiating Family Responsibilities*. London: Routledge, Oct. 1992.

[15] J. A. Parks, *No Place Like Home?: Feminist Ethics and Home Health Care*. Bloomington: Indiana University Press, 2003. [Online]. Available: https://muse.jhu.edu/pub/3/monograph/book/9154

[16] E. S. Short, E. C. Deng, D. J. Feil-Seifer, and M. J. Mataric, "Understanding Agency in Interactions Between Children With Autism and Socially Assistive Robots," *https://doi.org/10.5898/JHRI.6.3.Short*, 2017, accepted: 2019-06-05T15:36:09Z. [Online]. Available: https://scholarworks.unr.edu//handle/11714/5224

[17] C. S. Cobley, R. J. Fisher, N. Chouliara, M. Kerr, and M. F. Walker, "A qualitative study exploring patients' and carers' experiences of Early Supported Discharge services after stroke," *Clinical Rehabilitation*, vol. 27, no. 8, pp. 750–757, Aug. 2013, publisher: SAGE Publications Ltd STM. [Online]. Available: https://doi.org/10.1177/0269215512474030

[18] R. N. Metze, R. H. Kwekkeboom, and T. A. Abma, "'You don't show everyone your weakness': Older adults' views on using Family Group Conferencing to regain control and autonomy," *Journal of Aging Studies*, vol. 34, pp. 57–67, Aug. 2015. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0890406515000535

[19] G. C. Williams, Z. R. Freedman, and E. L. Deci, "Supporting Autonomy to Motivate Patients With Diabetes for Glucose Control," *Diabetes Care*, vol. 21, no. 10, pp. 1644–1651, Oct. 1998. [Online]. Available: https://doi.org/10.2337/diacare.21.10.1644

[20] P. Jennifer Piatt, M. S. Shinichi Nagata, P. Selma Sabanovic, M. S. Wan-Ling Cheng, P. Casey Bennett, M. S. Hee Rin Lee, and P. David Hakken, "Companionship with a robot? Therapists' perspectives on socially assistive robots as therapeutic interventions in community mental health for older adults," *American Journal of Recreation Therapy*, vol. 15, no. 4, pp. 29–39, Feb. 2017. [Online]. Available: http://www.wmpllc.org/ojs-2.4.2/index.php/ajrt/article/view/420

[21] S. Sabanovic, C. C. Bennett, W. L. Chang, and L. Huber, "PARO robot affects diverse interaction modalities in group sensory therapy for older adults with dementia," in *2013 IEEE 13th International Conference on Rehabilitation Robotics (ICORR)*, Jun. 2013, pp. 1–6.

[22] R. B. Jackson, T. Williams, and N. Smith, "Exploring the Role of Gender in Perceptions of Robotic Noncompliance," in *Proceedings of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*, ser. HRI '20. New York, NY, USA: Association for Computing Machinery, Mar. 2020, pp. 559–567. [Online]. Available: https://doi.org/10.1145/3319502.3374831

[23] L. Moradbakhti, B. Leichtmann, and M. Mara, "Development and validation of a basic psychological needs scale for technology use," 2022.

[24] B. Chen, M. Vansteenkiste, W. Beyers, L. Boone, E. L. Deci, V. der Kaap-Deeder, B. Duriez, W. Lens, L. Matos, A. Mouratidis *et al.*, "Basic psychological need satisfaction, need frustration, and need strength across four cultures," *Motivation and emotion*, vol. 39, no. 2, pp. 216–236, 2015.

[25] A. Heissel, A. Pietrek, B. Flunger, T. Fydrich, M. A. Rapp, S. Heinzel, and M. Vansteenkiste, "The validation of the german basic psychological need satisfaction and frustration scale in the context of mental health," *European Journal of Health Psychology*, 2019.

[26] K. M. Sheldon and J. C. Hilpert, "The balanced measure of psychological needs (bmpn) scale: An alternative domain general measure of need satisfaction," *Motivation and Emotion*, vol. 36, no. 4, pp. 439–451, 2012.

[27] V. Venkatesh and H. Bala, "Technology acceptance model 3 and a research agenda on interventions," *Decision sciences*, vol. 39, no. 2, pp. 273–315, 2008.

[28] K. Winkle, P. Caleb-Solly, A. Turton, and P. Bremner, "Mutual Shaping in the Design of Socially Assistive Robots: A Case Study on Social Robots for Therapy," *International Journal of Social Robotics*, Mar. 2019. [Online]. Available: https://doi.org/10.1007/s12369-019-00536-9

[29] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User Acceptance of Information Technology: Toward a Unified View," *MIS Quarterly*, vol. 27, no. 3, pp. 425–478, 2003. [Online]. Available: http://www.jstor.org/stable/30036540

[30] I. H. Kuo, J. M. Rabindran, E. Broadbent, Y. I. Lee, N. Kerse, R. M. Q. Stafford, and B. A. MacDonald, "Age and gender factors in user acceptance of healthcare robots," in *RO-MAN 2009 - The 18th IEEE International Symposium on Robot and Human Interactive Communication*, 2009, pp. 214–219.

[31] K. Winkle, D. McMillan, M. Arnelid, K. Harrison, M. Balaam, E. Johnson, and I. Leite, "Feminist Human-Robot Interaction: Disentangling Power, Principles and Practice for Better, More Ethical HRI," in *Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction*, ser. HRI '23. New York, NY, USA: Association for Computing Machinery, Mar. 2023, pp. 72–82. [Online]. Available: https://dl.acm.org/doi/10.1145/3568162.3576973