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Friendship with a robot: Children's perception of similarity between a robot's physical and virtual embodiment that supports diabetes self-management

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ABSTRACT

Objective: The PAL project develops a conversational agent with a physical (robot) and virtual (avatar) embodiment to support diabetes self-management of children ubiquitously. This paper assesses 1) the effect of perceived similarity between robot and avatar on children's' friendship towards the avatar, and 2) the effect of this friendship on usability of a self-management application containing the avatar (a) and children's motivation to play with it (b).
Methods: During a four-day diabetes camp in the Netherlands, 21 children participated in interactions with both agent embodiments. Questionnaires measured perceived similarity, friendship, motivation to play with the app and its usability.
Results: Children felt stronger friendship towards the physical robot than towards the avatar. The more children perceived the robot and its avatar as the same agency, the stronger their friendship with the avatar was. The stronger their friendship with the avatar, the more they were motivated to play with the app and the higher the app scored on usability.
Conclusion: The combination of physical and virtual embodiments seems to provide a unique opportunity for building ubiquitous long-term child-agent friendships.
Practice implications: an avatar complementing a physical robot in health care could increase children's motivation and adherence to use self-management support systems.

1. Introduction

Type 1 Diabetes Mellitus (T1DM) is a chronic disease that affects 17,000 new children per year in Europe alone [1]. T1DM, if poorly managed, can have life-threatening complications, such as blindness, kidney failure, heart attacks and lower limb amputation [2,3]. T1DM requires children to learn to constantly manage their condition regarding glycaemia monitoring, insulin injection, and regulation of diet and exercise [2]. This diabetes self-management can be challenging, and for most children aged 7–14, parents still play a leading role [4]. However, children who learn to self-manage their diabetes at an earlier age, are better to cope with it during puberty and after [5,6]. In recent years, robots have been developed to interact with humans, in order to motivate and increase their compliance in areas such as education, health and well-being [7,8]. Such social robots seem to provide new opportunities to help children, as a kind of friend, to cope with a chronic disease like diabetes.

In Human-Robot Interaction (HRI) an interesting and well-studied phenomenon explains the way we treat non-living objects such as robots: anthropomorphism. It is defined as "the tendency to attribute human characteristics to objects in order to facilitate understanding and interpretation of their actions" [9–11]. This phenomenon applies to the field of social robotics as well. People seem to automatically assign a certain level of intelligence and sociability to robots [12,13]. In Child-Robot Interaction (CRI) anthropomorphism seems to be even higher, because children have a different, not fully matured, cognitive development [14]. Therefore, children generally do not see a robot as a programmed machine but attribute living human- or animal characteristics to it [15]. Many studies have investigated children engaging in

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interactions with social robots. In a study of Kahn et al. [16] for example, 90 children between 9 and 15 years of age interacted with a humanoid robot, Robovie. Most of the children believed Robovie had mental states (e.g., intelligence and feelings) and was a social being (e.g., could be a friend) [16]. These findings suggest that children, in general, are likely to engage with robots and develop feelings of friendship towards them, which indeed is demonstrated by recent research [17–20].

Friendships are undoubtedly important in childhood; they are crucial to mental and physical health [21,22] and can facilitate learning and motivation [22]. The self-determination theory (SDT) [21] explains the latter by highlighting the concept of intrinsic motivation, which refers to engaging in an activity for its own sake because it is interesting and satisfying, as opposed to obtain an external goal (extrinsic motivation). According to SDT, the three building blocks for intrinsic motivation are autonomy (feeling in control of the situation), competence (feeling capable) and relatedness (the relationship between teacher and trainee) [21,23]. This teacher can also be a peer with whom the child builds a form of relatedness or friendship [23]. Thus, the SDT explains how friendship can facilitate learning: experiencing relatedness increases intrinsic motivation. In addition, to create friendships *on the long term*, regular exposure is of particular importance. The ‘mere exposure effect’ [24] states that the more people are exposed to each other, the more they start liking each other and the stronger their friendship will grow. We assume that these effects not only hold for human–human interaction but also for human-robot interaction. In that case, creating a bond between children and robots can be very beneficial, to increase motivation, learning, and adherence.

In recent years, many studies have shown that through bonding with a social robot, children with chronic diseases can be educated and motivated for compliance to health treatment [7,8,25–27]. The European ALIZ-E project (2010–2014) has developed a social robot to support diabetic children with their diabetes self-management. This robot proved to be a successful tool, serving as an educator, motivator, and friend during hospital visits [4,26–28]. However, as children with diabetes “only” visit the hospital four times per year, the need for a solution to continue diabetes self-management at home and possibly other locations arises.

In recent years, it is assumed that social robots do not necessarily need a physical body to interact with their users and can perform their tasks just as well through a virtual 2D or 3D representation, an *avatar* [29]. Using an avatar instead of a physical robot could offer great potential for long-term interaction because it allows for regular exposure [30]. Previous research has shown that including a virtual avatar in mobile health applications can substantially increase motivation and adherence to those applications [8,31–34]. The Personal Assistant for a healthy Lifestyle (PAL) project (www.pal4u.eu) started in 2015, and introduced a PAL agent that has both a physical (robot) and virtual (avatar) embodiment (see Figs. 1 and 2).

Children can perform several self-management supporting activities with this agent, either with the robot at dedicated locations or with the avatar via a mobile application (i.e., the MyPAL app). However, the question remains: will children like this avatar similar to the physical robot?

Although avatars offer a useful and low-cost alternative to a real physical robot, experiments have shown that children often react differently to an animated character [35,36]. As we have summarized in Table 1, both types of embodiment have got some advantages and limitations of their own.

To overcome limitations of both types of embodiment (i.e. physical robot and virtual avatar) and benefit from their advantages, it is possible to combine the two by complementing a physical robot with a virtual counterpart; giving the conversational agent the ability

Fig. 1. NAO robot.

Fig. 2. Interface MyPAL app with avatar.

to switch between embodiments [30,46]. To maintain the identity of the agent, it is important to present the two embodiments in such a way that users perceive they are interacting with the same entity. In a study of Gomes et al., children interacted with an artificial pet dinosaur that could migrate between a virtual agent on a smartphone and a physical embodiment [46]. They found that almost half of the children perceived the two embodiments as corresponding to the same entity. They also found that in order to improve this similarity it is important that the personality of the agent stays consistent in both embodiments. Furthermore, Martin, et al. [47] mention some important features that have to remain constant across different body forms as well, which they call ‘identity cues’. Examples of cues are colours, markings on the body, the type of character that the agent represents (human, dog, insect) and non-visual aspects such as the tone of voice or the agent’s behaviour or personality [47].

This paper describes PAL's experiment during a four-day diabetes camp in the Netherlands, in which the interactions between children and both a physical robot and a virtual avatar were investigated. Based on current literature, we hypothesize that when children (8–11) with diabetes perceive a high degree of similarity between robot and avatar, they will also experience a stronger friendship with the avatar, and in turn a higher motivation to play with the MyPAL app, as well as a higher usability of the app. See Fig. 4 in chapter 3 (Results).

2. Methods

2.1. Application scenario

The experiment conducted, as part of the PAL project, was held in October 2016, during a four-day diabetes camp for children diagnosed with T1DM in the Netherlands. The camp was organized by the Dutch Diabetes Association (DVN). During the camp, we tested and evaluated the PAL system, including both robot and

Table 1
Robot or Avatar? Benefits and limitations of both embodiments.

	Physical Robot	Virtual Avatar
Benefits	Real world interaction (allows for touch, etc.) [37,38]	More robust/durable
	More appealing [39,40]	Greater portability
	Greater social presence [41]	Greater proximity (exposure)
	Leads to higher expectations [41]	Suitable for long term interaction [30]
	Draws more attention [36,42]	Allows more complex interaction design
	More effective to increase learning [43,44]	Allows for 'customization' to the user
	More effective to increase long-term behaviour change [45]	
Limitations	High costs	Less appealing and pleasurable [39,40]
	Limited battery life	Less effective in behaviour change and learning [43–45]
	Need for mechanical maintenance	
	Wear and tear	
	Physical limitations in behaviour	

avatar, by exploring the opinions, expectations and real needs of end users (children).

2.2. The PAL system

The PAL system consists of a physical robot, its avatar and an application for mobile devices; the 'MyPAL app'. The dialog options between children and both robot and avatar were still limited. To communicate with the avatar, children could give their input via the screen of the tablet and the avatar gave its output through speech and gestures. To communicate with the robot, children could talk to it and its response was controlled by the researcher (see below). There was no free dialog and no personalisation in the system yet.

2.2.1. The physical robot

The robot used for the PAL project is NAO (see Fig. 1) a social robot that is well-suited for interaction with children [48]. The robot's behaviour is partially autonomous (movements, blinking of the eyes, body language) and partially controlled by a Wizard-of-Oz, (WoZ technique; see Gould et al. [49]). This implies that the robot behaves autonomously, but the researcher conducting the test partly simulates the dialogue model and the sensors from behind a laptop. The robot's responses can be chosen from the dialog model with optional questions and sentences or can be typed directly, and is then sent as output to the robot. The physical robot is used in hospital settings to decrease anxiety in children. The robot plays diabetes games and quizzes with the children, teaching them about diabetes and diabetes self-management.

2.2.2. The virtual avatar in the MyPAL app

The avatar is a 2D representation of NAO. It has a similar appearance as the physical NAO robot, and the behaviours of both robot and avatar are based on the same model. The avatar is part of the MyPAL application (see Fig. 2). The MyPAL app has different educative features for children to support diabetes self-management. When a child logs in into the MyPAL application, various modules are started on a server. The modules are generating the dialog text, selecting the questions during the quiz, generating the behaviours of the actor, estimating the child's emotional state, monitoring the goal progress and deciding on which action the child should take next. The avatar plays diabetes games and quizzes with the children, teaching them about diabetes and diabetes self-management.

2.3. Sample and procedure

A total of 21 children (aged 8–11) participated in the camp; among them 13 boys and 8 girls. During these four days, a variety of activities with both robot and avatar were organized, see Table 2 and Fig. 3 . All children were given the same opportunities and playtime with robot and avatar. Questionnaires were completed both on the first day of the camp (T1) and the last day of the camp (T2).

a

b

c

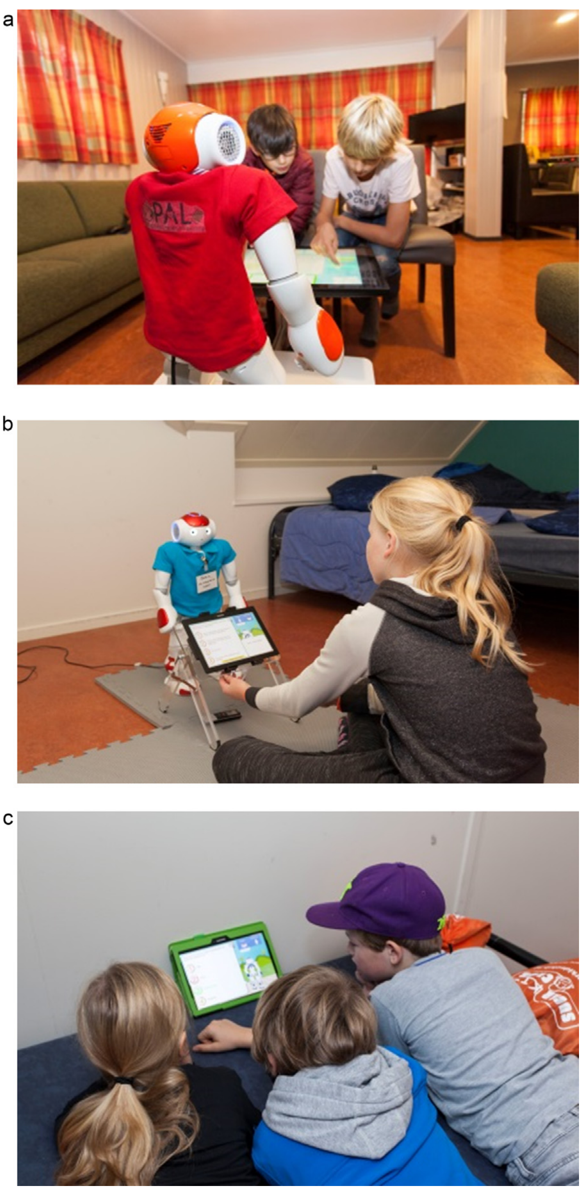

Fig. 3. Robot-rounds (a = sorting game with real robot, b = quiz with real robot, c = quiz with avatar in the MyPAL app.

Table 2
Research activities during the camp.

Activities	Tuesday (T1)	Wednesday	Thursday	Friday (T2)
Plenary talk, robots introducing themselves (approx. 30 min)	x			
'Small talk' in small groups (approx. 1 h)	x			
Playing with MyPAL app after dinner (approx. 30 min)	x	x	x	
Bedtime story by robots (20 min)	x	x	x	
'Robot-rounds': 4 games; 2 games (quiz and sorting game) with Robot, and the same 2 games with Avatar (3.5 h)			x	
Disco night with robot's dance performance (1 night)			x	
Completing questionnaire (30 min)	x			x

2.4. Measures

During the four-day experiment, we gathered both quantitative and qualitative data, using questionnaires, which were completed on the first day (T1) and the fourth day (T2) of the camp. Our four main variables similarity, friendship, usability, and motivation were scored quantitatively on Likert-scales with emoticons (see appendix). Children were asked to respond using a (self-chosen) stamp. Aspects that contributed to the perceived similarity of robot and avatar were measured qualitatively by open questions. As the participants' native language was Dutch, the questionnaires were in Dutch.

2.4.1. Similarity

Participants responded to the question: 'The robot on the camp and the robot on the tablet are the same one'. Answers were scored on a 4-point Likert scale, ranging from *totally not the same* (1) to *very much the same* (4). This question was followed by two open questions about which aspects of robot and avatar did or did not contribute to this similarity.

2.4.2. Friendship

To quantitatively measure feelings of friendship we took inspiration from the McGill Friendship Questionnaire [50]. The original questionnaire consists of 48 questions, divided over six subscales (Stimulating Companionship, Help, Intimacy, Reliable Alliance, Self-Validation, and Emotional Security). We decided to shorten the questionnaire (to minimize the burden of research on the children) by handpicking two questions from each subscale that we found most suitable for this situation, and adding one general question about friendship. An example of one of the questions regarding Stimulating Companionship was "I like playing with the avatar." Participants responded on a 5-point Likert-scale ranging from *totally disagree* (1) to *totally agree* (5). Participant's mean scores on 13 items were calculated to compute the scale. We used the same questionnaire to measure friendship children felt towards the physical robot, replacing 'robot on the tablet' by 'the real robot'.

2.4.3. Usability

To measure usability of the MyPAL application, we used the System Usability Scale (SUS) questionnaire [51] and slightly adapted the sentence structure of the questions to make them more suitable for young children. An example of one of the questions was 'I find the Robot-app easy to use'. Participants were asked to respond on a 5-point Likert-scale ranging from *totally disagree* (1) to *totally agree* (5). To obtain the official SUS value, the sum of the scores was multiplied by 2.5 (see Brooke [51] for details about calculation of SUS scores).

2.4.4. Motivation

Motivation to play with the MyPAL application was measured using one item, which said: "I would like to use the Robot-app more often." Answers were scored on a 5–point Likert scale ranging from *totally disagree* (1) to *totally agree* (5).

2.5. Analysis

After calculating Cronbach's alpha scores for reliability, scales were computed for friendship robot, friendship avatar and usability, both for T1 and T2. For initial within-group comparisons of our data, paired sample *t*-tests were carried out to measure differences between friendship robot and friendship avatar, as well as changes in friendship, motivation, and usability over time (from T1 to T2). To test our hypothesized model, we continued our calculations with scores of T2. A one-way independent ANOVA was used to calculate the effect of perceived similarity on friendship with the avatar, using Gabriel's post hoc tests to reveal the differences on friendship score between the different similarity answer categories. The effect size of similarity on friendship was retrieved by calculating ω^2. Because not all categories of our motivation variable were filled sufficiently, we transferred it into a dummy variable; merging categories 1, 2 and 3 ('totally disagree' to 'I don't know') into low motivation and categories 4 and 5 ('agree' and 'totally agree') into high motivation. A logistic regression analysis was carried out to measure the effect of friendship on motivation adjusted for sex and age. Finally, linear regression analysis calculated the effects of friendship on usability adjusted for sex and age. To see whether the results were significant, we used an alpha of .05 (two-sided) for all our analyses.

3. Results

3.1. Participants

Table 3 shows the characteristics of the participants. A total of 21 children aged 8 to 11 (*Mean* = 9.2, *Standard deviation* = 1.1) participated in the camp, among them 13 boys and 8 girls.

3.2. Scores on similarity, friendship, motivation, usability and motivation

Table 4 shows the scores of the participants on the variables. The Cronbach's alpha reliability scores of the scale measuring friendship on T2 with the robot was .90 and with the avatar was .91. The scale measuring usability of the MyPAL app on T2 had a Cronbach's alpha reliability of .86. All children preferred the physical robot over the avatar when they were asked to choose. Moreover, their feelings of friendship towards the physical robot (*M* = 4.0, *SD* = 0.6) were significantly higher than feelings of

Table 3
Characteristics sample of 21 children in diabetes camp in the Netherlands.

Gender: Boys (N (%))	13 (62%)
Girls (N (%))	8 (37%)
Age (years) (M (SD), (Min-Max))	9.1 (1.1), 8–11
Diabetes since (years) (M (SD), (Min-Max))	3.5 (1.7), 1–7

M = . . . mean, SD = standard deviation.

Table 4
Descriptive statistics of sample on the variables on day 1 (T1) and day 4 (T2) (N = 21).

	T1 (day 1)				T2 (day 4)				Differences T1–T2		
	Min–max	*M*	*SD*	*α*	Min–max	*M*	*SD*	*α*	*M*	*SD*	*p*
Preference robot(1)/avatar(2)	1–1	1	0	/	1–1	1	0	/			
Similarity R/A	1–3	1.8	0.9	/	1–3	1.8	0.8	/	0.1	0.9	.815
Friendship robot	2.9–5.0	4.0	0.6	.86	2.9–5.0	4.2	0.7	.90	0.2	0.6	.281
Friendship avatar	1.3–4.2	2.9	0.7	.84	1.1–4.5	3.0	0.9	.91	0.1	1.0	.577
Usability MyPAL app	27.5–95.0	56.1	17.2	.66	8.3–100.0	58.7	24.5	.86	2.6	21.7	.590
Motivation	1–5	3.6	1.5	/	1–5	3.7	1.3	/	0.1	0.9	.741

friendship towards the avatar ($M = 2.9$, $SD = 0.7$), $t(20) = 5.4 = p < .001$. Furthermore, paired sample T-tests showed that scores of friendship for both robot and avatar did not significantly increase from T1 to T2. In addition, there was no significant increase in motivation and usability scores from T1 to T2 either. The usability score of the MyPAL app on T2 was 58.7 ($SD = 24.5$). According to the official validation, a SUS score of 58.7 is considered a D (average) on a scale from F (failure) to A+ (out of standing) [51] which means that the MyPAL app scored average.

3.3. The relationships between similarity, friendship, motivation & usability

Fig. 4 shows the hypothesized model we tested. Because there were no significant differences between T1 and T2 we decided to use only the measures of T2 for a cross-sectional analysis. Hypothesis 1 represents the relationship between similarity and friendship with the avatar. Hypothesis 2 and 3 represent the relationships between friendship with the avatar and motivation to play with the MyPAL app and usability of the app. All relationships as shown in the model were significant.

3.3.1. The relation between similarity and friendship avatar

Participants were asked to score their perceived similarity in one of four categories, ranging from 'totally not the same' (1) to 'very much the same' (4). As the fourth option 'very much the same' was never chosen, we divided the participants into three groups (based on their score on perceived similarity). We compared these three groups on feelings of friendship with the avatar, see Fig. 5. Group 1, 2 and 3 consisted of 10, 6 and 5 participants respectively. Gender and age did not have significant effects and therefore were not included in the model.

There was a significant effect of similarity on friendship with the avatar, $F(2, 20) = 4.84$, $p = .021$, $\omega^2 = .52$. Gabriel's post hoc tests revealed that perceiving robot and avatar as 'a bit the same' (3) significantly increased friendship with the avatar ($p = .023$) compared to perceiving them as 'totally not the same' (1). There were no significant differences between categories 1 (totally not the same) and 2 (a bit not the same) ($p = .174$) and between categories 2 (a bit not the same) and 3 (a bit the same) ($p = .684$). However, results of the ANOVA, as well as Gabriel's post hoc test between category 1 and 3, showed an increasing friendship with the avatar when perceived similarity increased, which approved Hypothesis 1.

3.3.2. The relation between friendship avatar and motivation MyPAL app

Logistic regression analysis showed a significant effect of friendship with the avatar on motivation to play with the MyPAL app, see Table 5. The odds of scoring high on motivation (versus low) was 5.92 higher with every increase of 1 point on friendship. We excluded age and gender from the model because it did not increase the model's fit (increase of $X^2(2)$ was 2.08, $p = .354$). With these results hypothesis 2 was approved, showing the positive effect of friendship with the avatar on motivation to play with the MyPAL app.

3.3.3. The relation between friendship avatar and usability MyPAL app

Table 6 shows the results of the linear regression analysis conducted to test the effect of friendship with the avatar on usability of the MyPAL app. Results show that feelings of friendship of the child towards the avatar is positively correlated with the usability of MyPAL. Age and gender did not have a significant contribution.

3.4. Qualitative results

The results of the open questions are shown in Table 7. Children answered the open questions about why they prefered the physical robot and what they perceived as the main differences between robot and avatar. Children's responses were devided in the categories: capabilities, social prescence, the quantity of speech and movements, and the physical robot being 'cooler'. Overall, children stated that the physical robot was more (inter)active, more present and more capable of doing different things, such as dancing.

4. Discussion and conclusion

The findings of our study show that children feel stronger friendship towards the physical robot than towards the avatar. Furthermore, our findings indicate that when children perceive the

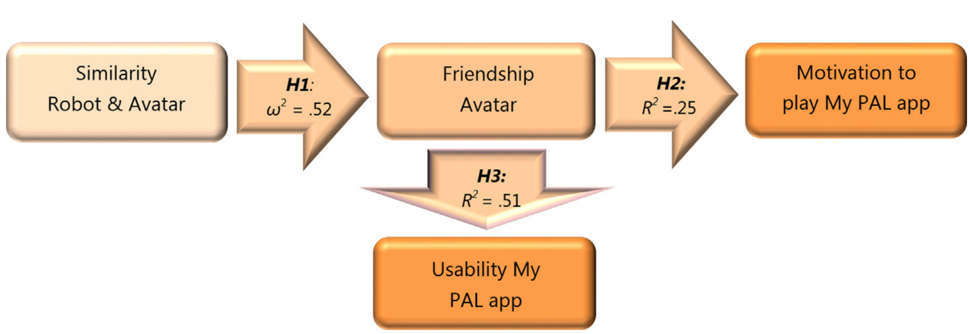

Fig. 4. The relationships in the model.

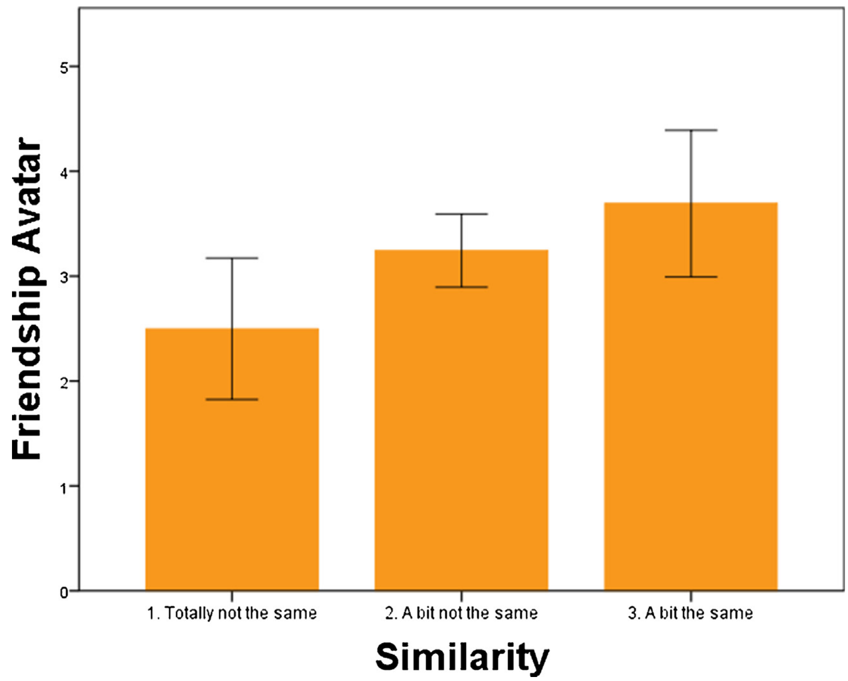

Fig. 5. The association between similarity and friendship.

Table 5
Coefficients of the model predicting motivation to play with the MyPAL app.

	B	95% CI for Odds Ratio		
		Lower	Odds	Upper
Included				
Constant	−5.01 (−31.86, −1.23)			
Friendship Avatar	1.78* (−.02, 401.22)	1.13	5.92	31.15

Note. R^2 =.25 (Hosmer & Lemeshow) .29 (Cox & Snell) .39 (Nagelkerke). Model $X^2(1) = 7.14$, $p = .008$.
* $p < .05$.

Table 6
Linear model of predictors of usability MyPAL app, with 95% bias-corrected and accelerated confidence intervals reported in parentheses. Confidence intervals and standard errors based on 1000 bootstrap samples.

	B	SE B	β	*p*
Step 1				
Constant	−1.29 (−20.24, 26.73)	12.20		.904
Friendship Avatar	20.04 (7.17, 28.54)	4.40	.71	.001
Step 2				
Constant	−9.38 (−40.63, 22.79)	16.35		.523
Friendship Avatar	21.62 (9.14, 33.49)	4.72	.77	.001
Age	6.36 (−8.36, 23.39)	8.33	.13	.463
Gender	.076 (−13.25, 14.84)	8.04	.01	.992

Note. $R^2 = .51$ for Step 1 ($p < .001$); $\Delta R^2 = .02$ for Step 2 ($p = .777$).

robot and its virtual counterpart as the same agency, they feel stronger friendship with the avatar, which confirms our expectations. In addition, the more children feel friendship with the avatar, the more user-friendly they perceive the MyPAL app, containing the avatar, and the more they are motivated to play with it. This confirms our hypotheses as well. Our findings are in line with previous research that found children are capable of feeling connected to a robot agent [17,19,20], and this friendship increases pleasure and motivation to play and learn [4,26,27]. The results of our study on perceived similarity are in line with work of other researchers as well, such as Gomes et al. [46] who found that children can perceive different embodiments of a robot agent as corresponding to the same entity [46], and Ogawa and Ono [52], who demonstrated the importance of using a virtual avatar *in addition to* a physical embodiment.

The PAL system, developed in the European Horizon2020 PAL project, allows both embodiments to complement each other: 1) the psychical robot initiates friendship in the hospital (reducing anxiety and making the hospital experience more fun), and 2) the portable and easy to access avatar extends this friendship further when children go home, enabling them to develop a long-term friendship with the agent. This could increase motivation to play with the app, and ultimately might improve diabetes self-management.

4.1. Enhancing similarity

The results of the qualitative part of our study give insight into what we can do to improve perceived similarity and feelings of friendship. We saw that of particular importance, according to the children, are the capabilities, the amount of spoken feedback, the movements and the overall social presence of the agents. This is in line with previous research that found that physical robots are mostly in favorite because of their real world interaction [37,38], and greater social presence [41]. However, an avatar allows for designing its appearance, colour, behaviour and even personality in a way that the individual child likes, i.e. it allows for customization, which could enhance perceived similarity as well [46]. We expect being able to customize the personality of the avatar to the wishes of the child, and increasing its activity level and speech, could develop the system further, and increase both similarity and bonding with the agent in the future.

Table 7
Qualitative results open questions.

Reasons preference physical robot	mentioned	Differences between robot/avatar	mentioned
Capabilities	7	Social presence ('real interaction')	5
Social presence ('real interaction')	4	Capabilities	4
It is cooler	4	Speech (quantity)	4
Speech (quantity)	3	Movements (quantity)	3
Movements (quantity)	3		

4.2. Recommendations for future research

The biggest advantage of current study was the opportunity of joining a camp of the Diabetes Association Netherlands (DVN) and conducting an experiment in a real-life setting. Twenty-one children diagnosed with diabetes participated in our experiments for four full days in a camp completely organized around our robots. One could still argue that four days is a too short period to develop a steady friendship. The short time between the first measure and the last is presumably an important reason why we did not find significant changes in the variables over time. However, the current study is an important first step in investigating similarity and bonding between children and a robot agent and the input of children during the camp will be used for co-creation of the system from the end user's (child's) perspective. The next step will be incorporating these results to improve the PAL agent and MyPAL app. Follow-up research with bigger samples and longer time-spans is then required to investigate the system further.

Furthermore, we did not see any effect of perceived similarity on friendship children felt towards the *physical robot*. This could be caused by the high scores of friendship children felt towards the physical robot (ceiling effect). We could imagine, however, that high perceived similarity between the two embodiments could increase friendship with the physical robot as well, when children regularly interact with the avatar at home, for longer periods of time. By being in contact with the avatar, children would be able to develop their friendship with the agent further and start appreciating also *the physical robot* more and more in time. Another question for future research is whether children develop their friendship with the avatar further from home, without being in contact with the physical robot. Because during the camp children were constantly in contact with both embodiments, we were not able to test this. These topics could be investigated in longitudinal studies. For instance, after initially meeting the physical robot in the hospital, one could let children to interact with the avatar from home for a few months and investigate whether both friendship with the avatar and friendship with the physical robot are increased.

4.3. Conclusion

Perceiving similarity between the physical robot and its avatar increases feelings of friendship children feel for the avatar and this friendship improves usability of the app and motivation to play with it. Since children are able to take their robot-friend home with them, they could deepen their friendship further, and start feeling more and more connected to the agent in time.

4.4. Practice implications

By complementing a robot with an as similar perceived avatar, one could create a system in healthcare education that increases children's motivation and adherence to it. Due to the special bond between children and the robot agent, children will feel supported to cope with and learn about their illness. We believe results of our study can be used for other educative (health) applications for children as well.

Conflict of interest

The author report no conflict of interest in this work.

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Appendix A.

Questionnaire

Similarity
1. The robot on the camp and the robot on the tablet are the same one

Friendship Avatar
1. The robot on the tablet is my friend/pal
2. I like playing with the robot on the tablet
3. I see the robot on the tablet as a friend that is always there for me
4. I trust the robot on the tablet
5. Sometimes I do not feel like talking to the robot on the tablet*
6. I feel supported by the robot on the tablet
7. The robot on the tablet often gives me compliments
8. The robot on the tablet understands me
9. The robot on the tablet is there for me when I worry
10. Even when I make a mistake, the robot on the tablet still likes me
11. The robot on the tablet is proud of me
12. The robot on the tablet helps me well
13. When I am sad, the robot on the tablet tries to cheer me up

Usability
1. I would like to use the robot-app more often
2. I think the robot-app is too complicated*
3. I think the robot-app is easy to use
4. I think I need help to use the robot-app*
5. I think the different things I can do within the robot-app fit together well and are much alike
6. I think everything in the app does not fit together well because sometimes things are different that I expected*
7. I think other children can learn to use the robot-app quickly and easily
8. I think that the robot-app in general is difficult to use*
9. I have a lot of confidence in myself when I use the robot-app
10. I still need to learn a lot to be able to use the robot-app better*

Motivation
1. I would like to use the robot-app more often

Open questions
1. Which robot did you like more, the real one or the one in the tablet? Why?
2. In what aspects did you think the two robots were alike?
3. In what aspects did you think the two robots were not alike?

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