Robin: An Autonomous Robot for Diabetic Children

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Abstract

We describe the cognitively and motivationally autonomous robot toddler Robin, designed as a tool to help children learn about diabetes management. The design of Robin follows an Embodied Artificial Intelligence approach to robotics, to create a robust social interaction agent, friendly but independent. We have used Robin in autonomous interactions with diabetic children in a scenario designed to give them mastery experiences of diabetes management in order to increase their self-efficacy.

1 Introduction

Robin (ROBot INfant) is a cognitively and motivationally autonomous affective robot toddler with "robot diabetes" that we have developed to support (perceived) self-efficacy, self-confidence and emotional wellbeing in children with diabetes, by providing them with positive mastery experiences in diabetes management in a playful but realistic and natural interaction context. Children with Type 1 diabetes mellitus (T1DM) are invited to play with Robin and look after it, including taking care of its diabetes. The children are thus given an opportunity of apply the knowledge they have acquired about diabetes and its management to manage someone else's diabetes in a playful non-stressful environment, with the aim to help them consolidate their knowledge, think how they would apply it to the management of their own diabetes, and develop a sense of responsibility towards self-management of their condition. The design of Robin follows an Embodied Artificial Intelligence (EAI) or Behaviour-Based approach to robotics [1, 2], relatively little-used by the Human-Robot Interaction (HRI) and Child-Robot Interaction (CRI) communities [3]. However, this approach is well suited to create a robust social interaction agent, friendly but independent, that is believable and engaging, and can be used in a real-world situation to interact autonomously with a wide variety of different children and interaction styles.

2 Type I Diabetes

T1DM is an incurable disease caused by the loss of insulin-producing beta cells in the pancreas, resulting in the body being unable to produce insulin naturally [4]. This leads to chronically raised blood glucose levels (hyper-glycemia) that needs to be corrected artificially by injecting insulin and balancing it with carbohydrate consumption. T1DM is often diagnosed in childhood and, if poorly managed, the high glucose levels lead to devastating complications such as blindness, limb amputations or organ failure. Childhood diabetes is a very challenging condition for the children, who have to learn about the condition as they grow, and the family, who will do the bulk of management for young children. In addition to the complex task of management, the emotional burden of chronic illness during childhood, accepting the responsibility for long-term health management in everyday life, and the impact of inevitable failures during the learning period, is associated with mental health problems [5, 6].

3 Robin

The Robin character has been designed [7, 8] as a tool to complement diabetes education for children. Robin is implemented in a Nao robot, controlled by our custom software that makes it behaves like a human toddler. It will autonomously make decisions based on its immediate motivations of hunger (resulting in it seeking the toy food objects provided), desire to socialise (it seeks and approaches human faces), desire to rest (it sits down), and desire to play (it dances). Robin also has an internal model of diabetes which results in its simulated blood sugar level fluctuating as it "eats" different foods, moves around or rests, as well as on its current

blood insulin level. High and low blood sugar levels will result in the robot becoming increasingly tired until it sits down and complains about feeling "sleepy". The robot's blood sugar levels can be monitored by the child using a wireless glucometer device that we implemented using a LEGO Mindstorms controller, and insulin can be administered using the same device. This allows the child (or anyone caring for Robin) to manage Robin's diabetes with insulin (to reduce blood sugar) and appropriate foods (e.g. glucose tablets to increase blood sugar).

Robin was designed to be autonomous in order that it could be used in different scenarios, and it would respond in an appropriate way. It was first used in a scenario conceived to improve children's perceived self-efficacy [9, 10] – briefly, perceived self-efficacy can be considered as the child's belief that they can succeed in learning how to manage their own diabetes; self-efficacy is considered as a key element in behaviour change, necessary for the good management of T1DM. In this scenario, the diabetic child, who already has theoretical knowledge about diabetes management, but who was not yet independent in their management, is first introduced to Robin by an adult, and shown how to manage Robin's diabetes. The child is then left alone to look after and play with Robin in the robot's "playroom" (a controlled environment, friendly-looking and familiar to the child). During this period, the robot would have a hyper- or hypo-glycemia (induced by the experimenters if it did not happen during the available interaction time). The child is then free to act as they felt appropriate, and could call for assistance if required. Since the aim here is to increase self-efficacy, it is important that the child could not fail. Therefore, if they failed to take appropriate action to manage Robin's diabetes, an adult could return and prompt them, or Robin could recover as though the sleepiness was not diabetes related.

4 Interactions

Interactions with Robin have been run with diabetic children (aged 8–12) at a hospital and a diabetes summer camp in Italy (with partners in the EU-funded ALIZ-E project[1], under which Robin was initially developed). Results from these interactions are reported in [11, 8].

Briefly, while self-efficacy was not seen to increase (it was not expected to, this is expected only from long-term or repeated interactions) the interactions were considered successful. The children engaged with Robin, and Robin acted appropriately as the scenario played out differently with each child. The "toddler" character successfully acted as a cover for the shortcomings in the robot (limited speech, no speech comprehension, occasional falls, and occasional behaviour that was difficult to understand for those interacting).

Several children showed spontaneous behaviour, such as hiding sweets from Robin, or making a bed. We view this as important because it is useful for the child to be able explore their own concerns related to diabetes, and an overly scripted interaction may limit this. Some of the interactions were done with two children looking after Robin together. Again, even though it had not been programmed for this specific scenario, Robin behaved appropriately, and the children acted together to manage Robin's diabetes.

A number of observations were made concerning the children's relating of their own diabetes with Robin's, such as checking their own glucometer in parallel with Robin's, or verbally relating their own experiences with diabetes in the context of Robin's. We view this as important since Robin was designed as an agent that the child could relate to emotionally, potentially forming a bond. This motivates the child to care for Robin, and in the process to learn about caring for themselves.

5 Future Work

Robin is currently a research prototype. We are working with healthcare researchers and a local NHS Trust, in order to explore future development (not limited to self-efficacy). To this end, a number of PPI (Patient and Public Involvement) interactions have been run with diabetic children and members of their families, in order to gather feedback towards further developing Robin so that it can be effectively used by health practitioners to support education in T1DM in children.

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