An Affective Autonomous Robot Toddler to Support the Development of Self-Efficacy in Diabetic Children

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Abstract— We present a software architecture and an interaction scenario for an autonomous robot toddler designed to support the development of self-efficacy in diabetic children, and discuss its potential medical benefits. We pay particular attention to the affective and social aspects of the interaction, as well as the importance of autonomy in the robot, examining their relationships to our scientific and therapeutic goals.

I. INTRODUCTION

In this paper we discuss how an autonomous robot toddler can be used to support the development of self-efficacy in diabetic children, and the rationale underlying our design, which pays particular attention to the affective and social aspects of the interaction. Our robot software has been developed combining principles of an embodied approach to cognition and interaction, developmental robotics, and the psychology of emotional development.

This work is a part of the ALIZ-E project (www.aliz-e.org) which aims to contribute to the theory and practice of social robotics, and in particular, of robots capable of interaction with humans over extended periods of time. ALIZ-E's research is done in the context of developing a companion robot for diabetic children (aged 8–12) as they learn about their diabetes.

Diabetes is a chronic disease with no cure, caused by a loss of the body's ability to synthesize insulin (Type I diabetes) or an insensitivity to insulin (Type II diabetes), either of which, if untreated, will lead to high blood glucose (glycemia) levels. Prior to the development of insulin treatments, the prognosis for Type I diabetes was almost certain death not long after diagnosis. The principal treatment for both Type I and Type II diabetes is (self-)management, through lifestyle/behavior-change and control of blood glucose levels with insulin injections and dietary control.

The paper is organized as follows: in Section II we consider problems related to self-efficacy and associated affective factors in children's learning of diabetes self-management skills; in Section III we describe a software architecture for an autonomous robot toddler with diabetes, and finally in Section IV we describe an interaction scenario between a diabetic child and our autonomous robot designed to support the elements identified in Section II.

II. MOTIVATION AND BACKGROUND

A. Growing up with diabetes

Diabetes is a very challenging disease, not only physically but also psychologically, particularly during pre- and early adolescence. Heller [1] writes: "It is difficult to conceive

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of a disease more likely to cause psychological problems than diabetes. Both Type 1 and Type 2 diabetes are lifelong incurable conditions with a strong heritable element, giving plenty of time for the development of guilt and recrimination within a family. Children who develop Type 1 diabetes are 'punished' by a series of injections and blood tests, a diet which forces them to eat when they don't want to and the prohibition of chocolate and ice cream, previously used to reward them for being 'good'."

Children with diabetes have great demands made put on psychological skills such as *emotion regulation* that are not mature in pre-adolescent children. In fact, as we will see in more detail in Section II-E, emotion regulation is developing in this age group, and this is one of the points where children of this age need most support. In addition, treatment requires changes in daily behavior that must be robust through adolescence (during which the way the body behaves changes) and into adulthood.

According to Diabetes UK (diabetes.org.uk), problems for our age group include:

- The acceptance of the diagnosis, the changes in the child's life, and hence the loss of aspects of their old life (referred to as a "grief process").
- Telling friends about their diabetes.
- Bullying or teasing due to diabetes.
- Fear of exclusion from activities due to diabetes. E.g. physical activities, parties, school trips, and treats.
- The child's diabetes, their "special" treatment, and the effect of diabetes on family life can be a source of jealousy or resentment from siblings.

Anderson and Brackett [2] note that: "The primary developmental tasks of the child during the elementary school years include making a smooth adjustment from the home to the school setting; forming close friendships with children of the same sex; obtaining approval from this peer group; developing new intellectual, athletic and artistic skills and forming a positive sense of self." These developmental goals raise issues related to self-esteem and self-confidence that can have a negative impact on diabetes management, in particular on self-efficacy, as we will see in Section II-D after having defined these terms in Section II-C.

B. Diabetes self-management

In infancy, the carer(s) of the diabetic child can be considered as the "patient". It is they who need to understand the condition, to manage the child's diet and insulin injections, and to be alert to symptoms of hypo- or hyper-glycemia. As the child grows, the management of diabetes is transferred from the carers to the child, who must learn to understand their own condition, and make decisions based on their own priorities, perhaps involving friends or adults.

Excessive independence is linked to poor glycemic control [2], and therefore some authors emphasize the need for controlling the transfer of responsibility. We prefer the alternative emphasis of Blanson Henkemans et al. [3] who state that "children need to be given more room to take responsibility for their illness and to take this responsibility early on and in a stepwise manner." Transfer of control should be made at a rate that is appropriate for the physical and emotional needs of the child, giving them *more* autonomy, rather than *complete* autonomy. We have taken this view into account in designing an activity which gives the child some level of autonomy, but in which they are expected to demonstrate their knowledge of good diabetes management, as highlighted in Section IV-B.

Problems with glycemic control during adolescence are common and may be partly associated with physical changes at puberty. This can lead to a lack of motivation to continue previously successful diabetes management behaviors. It is important that self-management behaviors are robust enough to survive this period.

C. Self-efficacy, self-confidence and self-esteem

We are concerned with a number of related "self-" concepts, which, synthesizing from the literature, we define as:

- *(Perceived) self-efficacy* – a person's beliefs about their own ability to successfully perform a specific task in a specific situation.
- *Self-confidence* – general feelings about one's own abilities. Self-confidence is thus more general than self-efficacy, and some authors talk of it in terms of generalized self-efficacy.
- *Self-esteem* – feelings about one's own worth. Self-esteem is related to self-efficacy, particularly to self-efficacy in those tasks that one holds as valuable.

Self-efficacy was introduced by Bandura [4] [5] as a key element in his theory of behavioral change. Since the goal of diabetes education is to promote good diabetes self-management behaviors in the child, Bandura's ideas tell us that it is essential that we seek to promote the child's self-efficacy in these diabetes management skills.

Bandura identified three dimensions of self-efficacy: *magnitude* (extension to more taxing situations), *generality* (extension to related tasks and situations), and *strength* (resistance to change, e.g. resistance to challenges that might make someone doubt their own capabilities). Bandura further identified four principal influences on perceived self-efficacy:

- Performance accomplishments or "Mastery experiences"
- Vicarious experience (e.g. social modeling)
- Social persuasion (e.g. verbal persuasion)
- Emotional state (e.g. perception of an increase in one's arousal when thinking about a task).

Our three "self-" concepts are closely interrelated, and in developing self-efficacy, the effects of the more *affective* aspects (self-confidence and self-esteem) on the transformation of self-efficacy beliefs (a *cognitive* construct) cannot be neglected. In this work, we are trying to support perceived self-efficacy with respect to diabetes self-management, and this includes working on the affective factors that surround it.

D. Self-efficacy, self-confidence and self-esteem in diabetic children

Problems related to low self-efficacy, self-confidence and self-esteem are common to all children in our age group. However problems on the affective side are aggravated in specific ways in diabetic children due to the perceived mismatch with other members of the peer group that negatively affects their sense of *belonging*, which is a very important element of this stage of emotional development.

In their survey of the literature, Anderson and Brackett [2] highlight "forming a positive sense of self" amongst the primary developmental tasks of the child during the elementary school years, and studies have linked levels of diabetic ketoacidosis with low self-esteem. Amongst the problems identified in this age group, these authors include teasing by peers, which can be particularly problematic for diabetic children if their need for regular blood glucose monitoring and insulin injections serves to highlight them as different from their peers. In addition to the self-esteem problem, this might lead to diabetes management problems with potentially serious health consequences, for example if the child copes with this stress by avoiding the proper management behavior, such as by not having their injection in order to avoid a situation that they perceive as socially negative. Anderson and Brackett also note the positive effects of extra-curricular activities on self-esteem and feelings of competence. In addition, a longitudinal study by Jacobson et al. [6] found that a child's initial reports of self-esteem and perceived competence were amongst factors that predicted subsequent adherence.

E. Emotion regulation and social play

At ages 8 to 12, children are developing their *emotion regulation* skills – these are "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions. Emotion regulatory processes may be automatic or controlled, conscious or unconscious, and may have their effects at one or more points in the emotion generative process" [7]. This ability is crucial for social adaptation, and indicates the capability of a person to modulate the effect of emotion on different processes, namely cognitive (e.g. attention), volitive (e.g. accepting delayed gratification, or acting contrary to their immediate wishes) and expressive (e.g. suppressing signs of anger or disappointment, controlling crying).

In our age group, the regulation of emotion develops towards more voluntary and cognitive forms of control, involving understanding of the consequences of their behavior [8], and is strongly embedded in the social context. This means that children are increasingly able to consider different behaviors, and to choose from amongst them based on their own goals, as well as an awareness of the social appropriateness of their actions.

Development of emotion regulation is itself a type of behavior change and its development is affected by self-efficacy – in this case a child's beliefs in their capacity to control their own emotions and how they express them. Bandura's four principal methods for influencing self-efficacy are thus pertinent, and in helping a child to develop their emotion regulation skills we can consider how to provide them

with *mastery experiences*, examples of emotion regulation in others, and social persuasion. Bandura's final influence, emotional state, additionally gives a dependency in the other direction: by increasing a child's expectations of mastery of their own emotions, they increase their self-efficacy in areas where emotion is a barrier to success. Therefore, by supporting the development of emotion regulation, we also support the development of self-efficacy in many areas.

Our scenario takes into account the role that socially directed play has on the development of emotion and emotion regulation. In particular, following Pellis and Pellis [9], we view socially related play with peers primarily as a context in which to develop emotion regulation (e.g. coping) skills, or learning to deal with the unexpected (rather than viewing play as training of physical and cognitive skills). For this, social play must introduce some moderate levels of novelty and stress, of the same kind that they are going to encounter in real life (i.e. related to diabetes self-management), but in a context that can be controlled by the participants, therefore eliminating the possibility that their actions might have serious consequences.

Moderate levels of stress have been found to be positive for the development of physiological and behavioral responses to stressors later in life. However, prolonged extreme (too high or too low) levels of stress have a negative impact – thus positive outcomes to exposure to stress follows a Wundt inverted U-shaped curve, as in theories of the effects of stress on cognitive and affective capabilities (cf. models by Hebb [10] and Berlyne [11] respectively). We have therefore designed our interaction so that it exercises the child's abilities in coping with moderate levels of "stress", uncertainty and novelty, while making it clear that it is in the context of a play situation, and there will be no serious consequences.

F. Autonomy in agents and robots

We follow Steels [12] and take an *autonomous* agent to go beyond a mere *automatic* agent by possessing a capacity to form and adapt its principles of behavior to some extent – at a minimum it should be self-regulating, or in a stronger sense it should also be *self-normative*, i.e. to make its own laws [13]. Steels notes that for an agent to be minimally autonomous, it must have "self-knowledge" (some awareness of its own internal state) and *motivations*. This highly adaptive quality makes autonomy an ideal property for an agent that is in a novel or a changing environment, and which needs to survive and continue to execute any tasks. McFarland highlighted that the behavior of an *automatic* system can be predicted if the internal basis of its decision-making is known, since the system will be minimally affected by environment due to the lack of active interaction with it. In contrast, an *autonomous* system retains a degree of unpredictability as its behavior is a side-effect resulting from its interactions with an unpredictable and changing environment [14]. However, because the autonomous agent is still acting based on internal drives, it is not simply behaving arbitrarily, or in a direction-less fashion, and even if its behavior cannot be predicted precisely, it can be both understood and influenced.
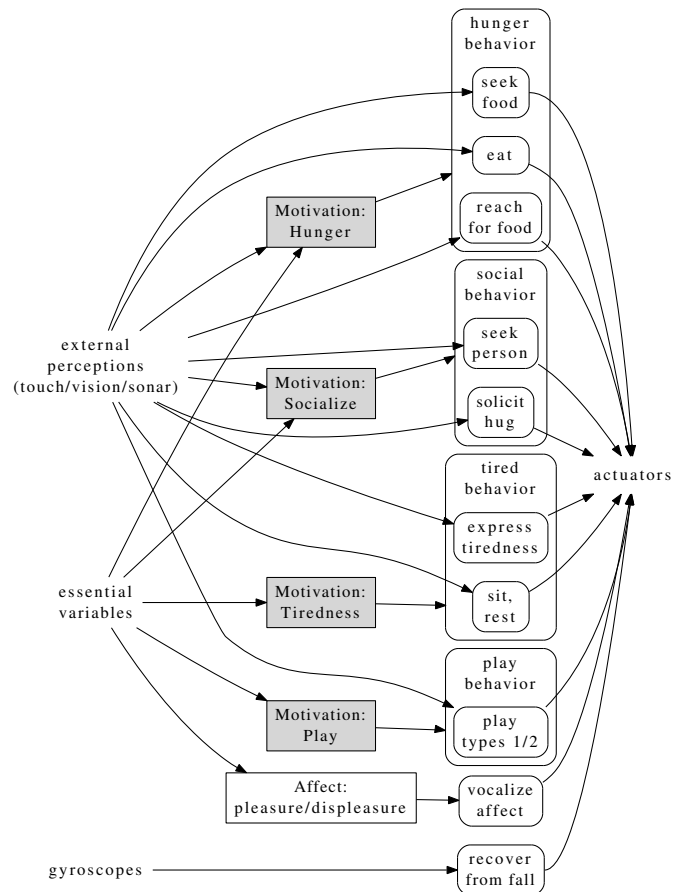

Fig. 1. Robot architecture

III. ROBOT ARCHITECTURE

Our architecture is designed to produce behavior approximating that of a toddler. The architecture driving the behavior of our autonomous robot follows an embodied approach in which cognition and action are tightly interrelated, and the overall behavior of the system results from the interactions between the robot and the environment. Following a definition of autonomy as self-regulation (Section II-F), the robot has a set of internal values that, in conjunction with the stimuli in the environment, motivate the robot to select the appropriate behavior to execute. We use the Aldebaran Nao, a 58cm tall humanoid robot, as our hardware platform. The architecture is implemented in UrbiScript and C++.

Like a toddler, the robot will switch between playing, looking for food, eating, looking for company, resting, sitting down, walking around, exploring the environment, and soliciting action from the child, depending on its needs. From the robot's point-of-view the interaction can be viewed as a multiple-resource problem – a task frequently used in behavior selection research. However, the nature of one of those resources is unusual: the child is a "resource" that provides the robot with social comfort. Since this resource is itself an agent, it may or may not provide comfort, depending on its own situation and motivations.

The main elements of this architecture, shown in Fig. 1, are as follows.

A. External perceptions

We use Nao's sensors to provide the following perceptions.

Software monitoring the head touch sensors signals short-duration contact (interpreted as "hits"), and longer-duration varying contact (interpreted as "strokes"). Software monitoring the chest-mounted sonars detects close contact (interpreted as a "hug") and nearby objects.

Video data is captured at QVGA resolution/8fps by Nao's in-head camera. A vision system using OpenCV then detects both faces and contiguous areas matching specific colors (used to detect a number of brightly-colored toys used as props in our interaction). Information about the detected objects can then be accessed by behaviors and motivations.

B. Behavior selection mechanism

The behavior selection mechanism is based on our previous activation-based behavior selection architectures such as [15] and [16]. Behaviors – perception-action loops linking sensors and actuators – have associated activation levels and activation thresholds. Each takes relevant sensor data and/or information about the motivational state of the robot, and asynchronously updates its current activation level. If the activation level is above its activation threshold, then the behavior is considered *active*, and is potentially executable. The selection mechanism periodically (8Hz) selects for execution the active behavior(s) with the highest activation levels. Our architecture allows multiple behaviors to be executed at once, as long as they used different groups of actuators – for example, the robot could vocalize (one behavior using the voice/speakers) as it walked (using the leg motors), while also turning its head (using the neck motors).

Behaviors can embed simpler behaviors – in our architecture the hunger and social behaviors (see Table I) are composed of simpler appetitive (goal-seeking) and consummatory (goal-achieving) behaviors. Since the higher-level behaviors are carrying out behavior selection, we have implemented these as instances, in the object-oriented sense, of the behavior selection class. Since the motivations are dominant in our top-level behavior selection (Fig. 1, the behaviors fed by gray boxes), we have a situation similar to the two-stage selection in the architecture described in [16].

C. Essential variables

To provide internal "values" to give the robot a basis for making autonomous decisions, the architecture includes a number of essential internal variables that it is motivated (see D below) to keep close to their ideal level: blood glucose, hunger, need for rest, need for play, and need for social interaction. As each variable moves further from its ideal value, the robot will become increasing motivated to execute behaviors associated with controlling that variable. Unlike typical models in the adaptive behavior literature, which are concerned with robots that manage those variables autonomously in order to survive, our robot will not "die" as a result of bad management of its essential variables. This choice was made for ethical reasons – to avoid overly stressing the children.

In addition to providing the robot with a basis for its motivations and decisions, we can use the essential variables as a guide to the robot's "well-being", which in our interaction

Motivation	Behaviors
Hunger	Search for food items / eat
Social interaction	Search for person / solicit hug
Tiredness	Sit down and rest / express tiredness
Desire to play	Play / explore

TABLE I

MOTIVATIONS AND ASSOCIATED BEHAVIORS OF OUR ROBOT

can be seen as a measure of the success of the interaction from the robot's point-of-view. In particular, the well-being with respect to blood glucose and needs for hunger and rest can be seen as measuring the quality of the care that the child provides to Nao. The well-being with respect to Nao's needs for social interaction and for play can be seen as measuring different aspects of the interaction style between Nao and the child.

D. Motivations

The mismatch between the current values of the essential variables and their ideal values trigger different motivations to act in order to correct the mismatch. The robot will attend primarily to the motivation that reflects the most urgent need (correcting the variable with the highest mismatch). However, there is room for opportunistic behavior (attending to a less urgent motivation) when the highest need is not too strong. The value of these motivations is calculated using a $deficit + (cue \times deficit)$ model, as in [16]. In other words, the motivation depends on the values of the driving internal variable, and the objects present in the environment that permit satisfaction of that need.

E. Low-level affect

We model one of the basic mechanisms underlying affect – "pleasure" and "displeasure" – with a hormone-like system. Summarizing the general dynamics of this system, release of the pleasure hormone occurs when the robot's needs (reflected by the internal variables) are satisfied, and release of the displeasure hormone occurs when the robot's needs to increase. In this model both pleasure and displeasure can occur at the same time, and can even be caused by the same event.

F. Behaviors

We have designed our robot behavior to approximate that of a human toddler. This has allowed us to create a scenario in which the robot will depend on the child for certain types of support, while also avoiding the risk of creating uncanny situations due to current technical shortcomings in producing the more cognitive behavior of an older child or adult (children might expect, for example, language understanding and the possibility of a dialog).

The robot is endowed with the internal motivations and associated behaviors given in Table I. We have deliberately designed our behaviors to allow flexibility in their interpretation, for example, a hand gesture could be pointing, reaching, asking for something, or whatever the child might interpret it as. The majority of the robot's the vocalizations are meaningless sounds with simple prosodic features associated with a positive or a negative affective quality, but they are not specifically about something (as a spoken word might be). Hence they can be interpreted in different ways by the

children, depending on the motivations that they might read into the robot's actions. The motivations that a child reads into the robot's actions could also be reflective of that child's own concerns. For example, if the child has a particular worry, they might interpret an ambiguous action of the robot as a sign of a similar worry in the robot. The vocalizations are linked to the "pleasure" and "displeasure" hormones and serve to give a window on the internal affective state of the robot and (if the child-robot relationship is positive) to encourage behaviors of the child that are positive to the robot (for example, helping behaviors), and discourage those that are negative (for example, continuing to feed when the robot is satiated). This opens the door to *sharing* between the robot and the child, and the joy or pleasure associated with sharing.

G. Diabetes model

The elements of our architecture described so far support only building self-efficacy in caring generally for the robot. To focus on the specific needs of our target users (diabetic children aged 8–12) we have also given our robot a metabolic model of blood glucose and insulin.

Blood glucose is increased by eating (the rate and amount depending on the type of food consumed), while the presence of insulin promotes the take-up of that blood glucose. In a healthy individual, high blood glucose causes the release of insulin, reducing the blood glucose back to the ideal range. The model running on our Nao is, however, a simple implementation of Type I diabetes: the natural level of insulin is very low, even in the presence of glucose, meaning that the glucose levels are not brought back down, and can stay unhealthily large (hyper-glycemia), and continue to grow as more carbohydrates are eaten. In order to bring the glucose level down, the child must add insulin to the robot's metabolism as appropriate, using the provided hand-held device, which also displays the current blood glucose level when activated. Giving too much insulin is also dangerous as it can reduce the blood glucose to unhealthily low levels (hypo-glycemia). Blood glucose is also affected by exercise and physical activity, which we have implemented in our model by making the glucose level fall more rapidly with increased current to the robot's motors.

In real life, the behavior of blood glucose is much more complex that in our model, appropriate treatment for hyper-/hypo-glycemia is correspondingly complex, depending on many factors, from the time of the day, recent activity levels, recent foods eaten, individual factors, etc. With time, diabetic children are given increasingly complex instruction in diabetes self-management. The children we are targeting with our interaction have enough knowledge to understand the simplified model of diabetes in our robot, but not the more complex knowledge. Since we are concerned with developing self-efficacy, rather than knowledge gain, our model is designed to ensure that the children will have the knowledge required to deal with the situation, and only have to focus on applying it in a specific context. The children will be given signs of positive affect and friendliness by the robot to build their self-confidence and self-esteem, regardless of whether they do well or not in the "task" of applying diabetes management knowledge. To give them feedback

when they have succeeded in applying knowledge, the robot will additionally show clear signs of "happiness".

IV. INTERACTION SCENARIO

A. Scenario

A diabetic child, who has volunteered to play with a robot, is told that this is a game "like a movie" in which both they and the robot are going to be actors playing different roles. The child is introduced to a Nao robot that is running the software described in section III. The child is told that they will play the role of an elder sibling of the robot, which will play the role of a toddler, and an adult is also present, playing the role of a parent. The robot will have its own "goals" or motivations to act autonomously, engaging in social behaviors, playing behaviors, or eating behaviors. For the eating behaviors, a number of toy plastic food items are present which the robot can "eat" (mime taking the food to its mouth). The child can then interact with the robot, initially with the assistance of the adult who can show the child the interactions available with the robot: how to feed and play with the robot, and through which sensors the robot can perceive the world and the child (Section III-A). The child is additionally told that the robot *also* has diabetes, and shown how to use the robot's hand-held glucometer/insulin device. This device displays the robot's current blood glucose level, and can therefore be used to assess when to give a dose of insulin to lower the blood glucose. The device can also be used to deliver doses of insulin to the robot. The food items in the scenario provide a way to increase the blood glucose. The children in this scenario will already have a knowledge of diabetes sufficient to understand healthy blood glucose levels and the effects of insulin and different types of food.

After this introductory period, the "parent" says that they need to leave the child and robot alone, while the parent either goes shopping, or does chores in another part of the home (depending on what is considered appropriate after an assessment of the confidence of the child). The child is told that they need to look after the robot, as they would look after their little brother or sister. The child is also given the task of doing some homework (typically a diabetes-related quiz). In the case where the adult is leaving the room, the child is provided with a phone with which to call the adult back, if needed. While the adult is away, the robot, as it is "going about its business", starts to display symptoms of either hyper- or hypo-glycemia. As in humans, many symptoms displayed by our robot are ambiguous – for example, tiredness and headaches can be associated with both hyper- and hypo-glycemia, but non-diabetics also get tired and have headaches, so these symptoms do not necessarily indicate an unhealthy blood sugar level. In real life, the correct management behavior is to first check the blood glucose level to determine if the symptoms are really related to the robot's blood sugar. Then a treatment is to be given, either an appropriate dose of insulin, or some food containing carbohydrates. The choice of a correct treatment is made more complicated by the dependency on what the diabetic person (or our robot) has been eating recently, their activity level, and prior doses of insulin. In order to check that the treatment has had the desired effect, the blood glucose levels should be checked again after a few minutes. This would

be the correct treatment that the children should apply to the robot. If this is done, the robot should be seen to have recovered from the episode of hypo-/hyper-glycemia, to "be happy" and to socialize "happily" with the child.

Since we want to avoid feelings of distress in the child if, for any reason, they fail to apply the correct diabetes management knowledge, the robot never shows extreme symptoms and ends up spontaneously recovering, as though the symptoms were not linked to diabetes.

B. Benefits for self-efficacy and self-esteem

The children invited to take part in this scenario should already have the necessary *knowledge* of diabetes to manage the situations presented in the scenario, and have demonstrated this in the highly controlled, safe environment of a written questionnaire. In terms of Bandura's theories of self-efficacy, we are giving the child a *mastery experience* of diabetes management, and this mastery experience should then increase the child's self-efficacy. While passing a written test also gives a mastery experience, by providing in our interaction a very different, and affectively engaging, expression of the child's knowledge, we hope to increase their self-efficacy in its magnitude, generalizability and strength, more than by another written test or similar demonstration of theoretical knowledge. In addition, practicing diabetes management in a semi-controlled play situation is closer to our targeted area of self-efficacy: diabetes *self*-management in an *un*controlled situation (real life). Since we use an autonomous robot, the encounter is genuinely less controlled than a scripted encounter – not even the robot designers know exactly what the robot will do, due to the uncertainty of emerging behavior in the interactions of an autonomous robot and a real physical environment. Since self-efficacy is generalizable to some extent, by increasing self-efficacy in our scenario, we are increasing it more in our target area than a written test or a controlled scripted scenario would do.

The social aspect of our interaction is also designed to support self-efficacy and self-esteem. By providing our robot with social behaviors in order to build a bond between the child and Nao, we hope the child will care both about Nao's well-being, and about Nao's regard for them. Hence the child will be affectively involved with Nao's fate during the interaction, and by experiencing a diabetes management scenario that is emotionally involving they will be better able to cope with the emotions of a real self-management experience – this links with the last of Bandura's principal influences on self-efficacy: emotional state. In addition, if the child values Nao's well-being then they are motivated to value diabetes management skills as they relate to Nao's well-being, and in valuing these skills they are motivated to improve them, in order to increase their self-esteem. Also, by improving Nao's well-being during the interaction they are doing something that they value, helping to boost self-esteem.

Finally, by seeing Nao come through an episode of hypo- or hyper-glycemia and still be happy, we are giving the child a *vicarious experience of a positive attitude* in the face of a setback. This relates to Bandura's second principal influence on self-efficacy, but now we are concerned with *self-efficacy in emotion regulation*. Since Nao is playing the role of a toddler – much younger than our child – if the child makes

inferences by social comparison, they should expect themselves to be able to show better emotion regulation than Nao.

V. CONCLUSION

We have presented a scenario for interaction between an autonomous social robot and a diabetic child, designed to support the development of the child's self-efficacy in diabetes self-management, as well as the strongly related human affective factors of self-confidence, self-esteem and emotion regulation. We use an autonomous robot, with its own motivations, in order to (a) develop affective bonds expected to increase engagement and motivation in children, and (b) confront the child with mildly unexpected, unpredictable (but not random) situations. As prescribed by theories of play as exposure to controlled moderate levels of stress, our reason for this is to help them develop emotion regulation and diabetes self-management skills that they can later use in real life.

Tests of our system with diabetic children are under way.

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