Get Up and Move: An Interactive Toy that Measures (In) Activity and Stimulates Physical Activity

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Abstract. Health experts are worried about the increase in overweight and the decrease in activity levels, particularly amongst youngsters. This project explores the possibilities of using interactive toys and social interaction in encouraging children to reduce their sedentarism. The project consists of a stuffed puppet which has an accelerometer to record the child’s (in)activity, and interactive elements. The puppet enables young children, aged 4 to 8, to care for it through their own physical actions. To arrive to the final concept a research was carried out on the barriers and motivators for children to engage in physically active play. On the basis of that knowledge four key elements were used to develop the product: fantasy, social interaction, surmounting physical and cultural barriers and inspirational factors. Two pairs of prototypes were tested. First limited tests indicated that the toys’ key elements were appreciated and understood, and suggest that it is possible to use interactive toys and social interaction to change the physical activity behaviour.

Keywords: Interactive toy, physical activity, sedentary behaviour, social interaction, fantasy, obesity, health care.

1 Introduction

Recent studies show that the increase of overweight in children and adolescence in the last decade is significant, and at the same time children’s level of physical activity and physical performance has declined [3, 4]. Some reports highlight the role of digital technologies (television, videogames and computers) in shifting children’s play into sedentary experiences [2, 12].

However, media have recently been used to increase physical activity (PA), and have become promising in the prevention and treatment of obesity in youth. Examples are the success of Nintendo Wii®, DanceDanceRevolution® and Xerbike®.

The goal of the project was to develop a product that measures children’s inactive time and motivates them, when needed, to reduce their sedentary behavior and increase their physical activity (for a detailed description of the project, see [15]).
2 Research

Literature research, interviews and generative session were used as research methods. There is vast documentation regarding (in)activity in children. Complementary interviews and generative sessions were carried out to gain empathy with the users. The main results of the research are:

2.1 Sedentary Behaviour and PA in children: The I-change model

A behaviour change is required to shift from sedentarism to activity. For that reason a behavioural change model was chosen to identify the motivational mechanism and the procedures necessary to promote change from sedentary behaviour to an active behaviour. The Integral model of change, I-change model, [19.23] originally used for reducing smoking in adolescents, was chosen (Figure 1).

Figure 1. I-change model [23] shows which factors contribute to behaviour change.

All factors of the model related to sedentary behaviour and physical activity are relevant, but only the ones that turned out to influence the design decisions are described below; we will not explain information factors, awareness factors and ability factors.
Predisposing Factors. Gender is an important biological predisposing factor. Compared to boys, girls show higher levels of overweight and obesity, exhibit lower levels of physical activity [12, 22], and experience steeper declines of PA during adolescence [4, 8].

Sociodemographic factors like low income, ethnic minority, single parent and overweight parent are consistently related to TV viewing and overweight in children [1, 11, 24, 25].

Motivation Factors. For young children enjoyment could be the most important determinant of the attitude towards PA [6]. From the interviews it was concluded that children participated in a sport or played actively when they enjoyed doing it.

Social influence is primordial. Many reports show that parental support is consistently conductive to greater amounts of physical activity [10, 27], and that family exerts a tremendous influence on health-related behaviours such as exercise [6]. During the interviews it was noted that parents are the main influence factor in the duration and frequency of outdoor play, which is dependent on their parent’s time and mood. Participating in sports and the regulation of some sedentary behaviour such as TV viewing and computer use is determined by parents. Friends are a second important stimulator to play outdoors, participate in sports or change from a media use activity to another type of play.

Barriers. Diverse environmental factors have an important role in the levels of physical activity in children. Among the negative factors are dog waste, high traffic and high rise buildings [8, 25].

Interviews revealed that young children can only play outside by themselves if they live in a house (or first level of an apartment), in a low or none traffic area and far away from canals (if the children could not swim). Even when living near playgrounds, many children living in areas considered unsafe by their parents, do not go to playgrounds often since they cannot go by themselves.

Cultural background also plays an important role. Some parents do not allow their children to go outside, since they are scared of bad influence from other children [1].

2.2 Relationship between Media use and Overweight

A study done for Jantje Beton [13] (Dutch association that stands up for the chance to play for all children in the Netherlands) by TNS NIPO (The Dutch Institute for Public Opinion and Market) says that 53% of children give as reason for not playing outside the TV or the Computer. All the interviewed parents mention that their children preferred to watch television to almost any other activity if they were allowed to.

Some researches [11, 12] show that television viewing and electronic game/computer use are somehow associated with adiposity.

Janz et al. [14] in a study relating television, physical activity and fatness in the adiposity rebound period (4 to 6 years), concluded children who on average watched 1 h or less of TV had 3% less body fat than those watching more than 3 h.
Several countries now recommend a maximum of two hours per day of electronic media use in children's physical activity guidelines.

2.3 Children’s Play and interests

Piaget made a classification of play, based upon which type of play children execute at different stages [26]. Symbolic play (stories and roles) is the main type of play for children aged 2 to 5, and construction play for children aged 4 to 8. Parents affirmed that their children could play for hours at construction and fantasy play (symbolic play), independently of the type of child and gender. However, the girls’ and boys’ ways of playing can be very different [18].

2.4 Technology and children

As explained before, children are much attracted to technology products such as TV and computer games and use them on a daily basis. These are barriers to perform physical activity, but some of their aspects can be used to stimulate physical activity.

Crawford [5] gives several reasons why people play videogames. Fantasy is one of the main reasons. He believes that people need to escape from their daily routines and fantasize. He explains that through the fantasy people can overcome social restrictions and that video games also provide the means of proving oneself. Malone [16, 17] estimates that of all the features a computer game has, fantasy is the most important feature that can be usefully included in other user applications. In his diverse studies, he explains that there are four main factors that motivate the use of specific video games: fantasy, curiosity, control and challenge. Games are appealing by evoking the users’ curiosity. Environments can evoke curiosity by being novel and surprising. Sounds and images are usually used to enhance the curiosity [5, 7, 20] and contribute to the players’ immersion in the game and concentration by providing sensory "proof" of the game’s reality. The challenge is determined by the relation between the players’ abilities and the complexity of the task. Personal meaningful goals with uncertain outcomes are beneficial to the challenge.

3 Concept Development

3.1 Key Elements Considered for the Design

The research provided a number of key elements to apply to the product. One of the main factors was to surmount the environmental and cultural barriers. Since many children cannot freely play outdoors, their natural play area (inside their home) could be adapted to allow them to have more physical activity. Even if the solution was focused on inside play, the play should provide a motivation factor to be used outside as well, since outdoor play stimulates physical activity and some parents do not appreciate their children being active inside the house.
Social interaction was another main aspect to consider for the object, since parents and/or friends play a major role in a child’s behaviour. In addition, it was decided to use fantasy as a central factor for the solution because fantasy games are often played by children, and it has proven to be effectively used to attract them to play video games or watch television. In this project, fantasy was used contrariwise to attract children to physical play, away from television and computer. Some video game aspects such as curiosity, control and challenge were decided to be used to support the fantasy.

3.2 Design Approach

To facilitate the exploration of possible concepts and develop the user’s experience and the physical components for the product, prototyping was introduced early in the design process. Different concepts were created and parts of it were tested to learn from the users’ reactions. Features that took into account the key elements were kept from each concept and further developed in the next one.

3.3 Technology

In order to reduce sedentary behaviour when needed, it was necessary to measure it. For that an accelerometer was used to measure (in)activity. RFID technology was used to have the toy react to different objects. The data was received in software Max/MSP which also controlled the sounds, vibration and/or lights, creating the toy’s behaviour.

4 Final Design

The final design consists of a puppet called Gum. A Gum is small creature that needs to be taken care of by a child. The child’s mission is to make his/her Gum healthier and happier by moving with it, feeding it and playing with it. A resume of its functions is given in figure 2. A Gum can pronounce words and emits sounds to ask for things or show its mood. It can also light up its ears and stomach and vibrate to communicate. Together with the Gum a child will obtain a group of objects (to feed and play with the Gum), a small story to learn about the Gums, a parents’ guide and a charger.

A Gum is healthy and happy when it has a minimal amount of daily physical activity. Since a Gum cannot move by itself, the child needs to do it. The Gum is placed in a special pocket which is attached to the child’s waist, in that way the Gum will sense the child’s physical activity. For the child it is a type of baby carrier.

Gum’s food has to be placed in different parts of the house by the children together with parents. A Gum wants to eat when the child has been inactive for a long period of time. It will tell the kid in a Gum language (similar to toddler’s language) which food it wants to eat. The child will take the Gum to where the food is placed (See
Figure 3); it makes different noises depending on the food it is asking for or eating. The type of food a Gum eats changes over time.

As the Gum gets healthier, lighted stars will appear in its ears, until it reaches a maximum healthy state. To increase the number of stars, the child needs to progressively increase and later on maintain its physical activity level. This takes several days, and up to a month in the last levels.

Gums also react to the child’s daily activity. The stars in the ears are brightly illuminated only if the child does the required PA (depending on Gum’s level), and dim when the child does not do it. The Gum can get angry if it has not moved enough and happy if it has. Besides moving around with the child, the Gum needs to eat, drink, play with friends, etc.

Even though a Gum is similar to a Tamagotchi [21] or a Furby [9], Gums invite children to be more physically active and move through the house, inside and out. Tamagotchi is a nurturing personal digital interactive toy and Furbies are interactive pets that encourage children to talk to them.

Figure 2. Gum’s activities and components
4.1 Social games with the toy

Gums like to play with their favourite toy (ball) and pet (spider). When the Gum touches the ball (or the spider) a sound is heard, after touching it for a number of times (depending on the level) the Gum will blink its ears and say “yuppi / yuhoo”. The games can be freely played by the child. A Gum can also ask to play a game, if it senses the child’s inactivity for a long period.

Due to the simplicity of this type of interaction many games can be played. With an added timer, some competitions can also be made. A game example is running from the ball/spider: the child runs to escape from the ball/spider that the parent or friend is carrying, when the parent/friend touches the Gum a number of times, he/she wins. If another child has a Gum, more games can be done, for example the fastest to touch the adversary’s Gum (with the ball or spider) a number of times wins.

Besides the previous game, there is another game that can only be played with two Gums and a set of toy eggs. Children race against each other to see who finds the eggs the fastest. The fantasy consists of the Gums wanting to kiss the eggs and wake up the birds inside the eggs. However birds are not always happy when woken up. The first Gum to make four birds happy wins. The child will either hear a happy or an angry bird sound when touching an egg with the Gum. The Gum who wins vibrates and says “yuhoo”.

4.2 Key elements used for the design

The four key elements derived from the research were applied in the final design as follows:

**Fantasy.** Children can get very attached to their own toys, especially to stuffed puppets which can be easily hugged, kissed or petted. A Gum is meant to be a special partner, almost like a pet. The chosen activities are similar to living creatures’ activities: eating, going to the toilet, getting cleaned, playing with friends and pets. The accompanying story helps children to get immersed in the fantasy.
Social interaction. Different ways are used to stimulate social interaction. First with a friend, a child will want to show how she/he has helped her/his Gum to become healthier, the number of stars in the ears will be displayed and comparisons can be made among friends. The kissing eggs game can only be done when a child is with someone else. Playing with the ball and the Gum is more exiting if more children are playing.

Parents will have a guide of the correspondences between the level of the Gum and the quantity of physical activity asked. In that way they will be aware of the PA their child does. They can motivate their children and even do some extra physical activities with them to make the Gum healthier, and the child happier.

Inspirational factors. The game was inspired by some video game qualities: goal, challenge, curiosity and control. These factors serve to support the fantasy. In this case the main goal is clear: make the Gum healthier and happier by being active. The challenge increases as the time passes by, first the Gum will rapidly increase stars without major effort, and progressively need more activity to change. Curiosity is engaged since the child is curious of what will happen: when is the Gum talking, when are the stars going to appear? The curiosity is supported by the sounds, vibration and lights. The child can have control over some actions by ignoring the Gum and by asking the Gum to play or eat.

Surmount cultural and environmental barriers. As explained before, these barriers are surmounted by allowing the child to use the Gum and do some physical activity at home, since many children cannot play freely outdoors. However, the game is not restricted to indoor play and can be played outside.

5 Testing

Two pairs of prototypes were made to test the concept, prototype 1 used sensors that needed USB connection to a PC, and prototype 2 allowed wireless communication to the computer. The final design is intended to function without an external computer.

5.1 Test set up

Testing the prototype was divided in two different test set ups. The first set up consisted of a series of short tests with eleven children aged 4 to 8, lasting two hours each. For technical reasons they were conducted with a Gum attached to a computer with a long wire. The second setup consisted of one longer test done with one seven year old boy one hour daily, during 10 days. This test was done with a wireless Gum. Before the actual tests were conducted, the story together with the parents’ guide was sent to the family’s house.
The first test’s main purpose was to observe the reaction of the children and parents towards the whole concept and the understanding and appreciation of the key elements. Different parts of the interaction were tested: feeding, ball game and eggs game. The Gum’s mood and evolution was not tested with children, only discussed with parents, since it was not possible for the toy to evolve or have a specific mood in a short time frame. The second test served to observe those elements that required longer time of use.

Both tests had some limitations. The novelty of the toy, the presence of the tester, having the Gum commanded by a computer and the small number of participants might have affected the results. Whenever possible, it was tried to verify observations and findings from children’s sessions through interviews with the parents.

6 Test Results

Both children and parents showed a good appreciation and understanding of all key elements:

- Fantasy: it could be observed that children believed in it. After reading the story they all remembered it, most parents mentioned that their children were impatient to meet the Gum. Many children, especially girls, showed signs of affection to the puppet such as hugging and kissing. During the long test, the boy wanted to care for it. He was affected when the Gum was angry, and tried to please him. He demonstrated his love for him by playing with it, sleeping with it or talking to it. No participants expressed a dislike of the narrative or the character.

- Social interaction: children showed social interaction by sharing the fantasy with others. In the first test, children explained the story and the Gum to each other. They were animated while telling the story and explaining how everything worked. They showed good comprehension of the concept and remembered most of the details. During the long test the boy’s brother was almost as happy as the testing boy when the Gum lit up a new star. Parents participated with children to place the food objects and by reading the story together.

  Children were more excited when other children were also present. The more they were, the longer they played each game. They preferred the eggs game, which can only be done with two Gums. When many children were present, they teamed up to help each other find the eggs faster.

  With the ball game, children had an active physical activity (See Figure 4) for more than 30 minutes, especially when more than two children participated in the game.

- Curiosity: it was observed that the sounds and vibration helped the children get immersed in the fantasy. All children responded to the Gum talking and wondered what the Gum would ask next. Most kids found the sounds funny and smiled or laughed after hearing them. Parents did not consider the sounds annoying.

- Control: during the second test, the tester showed wanting to have control of the Gum and the game. He often made the Gum want to eat, before the Gum would ask it. He had a table to mark every time the Gum asked for a new food. When watching
television, in some occasions, he ignored the Gum once or twice and fed him when he thought that the TV show was almost over.

- Goal: the boy in the second test showed comprehension towards the goal of having many stars through physical activity. He asked everyday if the Gum had been informed about him swimming and eventually he would tell the Gum himself. He mentioned several times wanting to be active in order to have a Gum with many stars and eating more food.

![Figure 4](image.png)

**Figure 4.** Comparison of the intensity of each activity done with a Gum to other types of play. Each value count corresponds to five seconds of activity. The activity level refers to the calculated velocity between accelerometer values.

- Reducing sedentary behaviour: It was observed that with the puppet it is possible to reduce sedentary behavior and increase PA, however physical activity is not necessarily prolonged after interacting with the toy. During the second test the boy always paid attention to the Gum when it asked for something. However, when it was during a television show, he would ask the Gum “Why do you want to eat now?” and get upset. During the first days of the test, he would always get up and feed the Gum, going back and forth from the television to the food. Then, he was told that he could ignore the Gum. He did it, but when the Gum got angry, he was very surprised and felt bad about making the Gum angry. He immediately got up and fed it.

- Increase PA: It was observed that children could be very active while playing with the Gum and that it is possible to increase PA by wanting to make it happy. Children were active when playing the different games, especially the ball game. The eggs game and feeding the Gum were observed to be moderately active activities (see figure 4).

During the second test, the child increased his physical activity inside the house, and mentioned that he was running in order to light more stars in the Gum’s ears. He was emotionally expressive whenever the Gum lit up a star or asked for a new food. He showed this by singing and sharing the moment (see Figure 5).
Figure 5. Being happy when the first star appeared.

Most parents expressed that they appreciated the toy; only one thought that her boy would not use it for a long time. Most parents mentioned they thought that their children would be motivated to move more thanks to the star system. They think that it is also motivating for the child when the Gum makes happy or angry noises.

7 Discussion

It can be discussed that the enthusiasm shown by the children towards the toy was a first reaction to a new toy or influenced by wanting to satisfy the tester. However some indications suggest that children are interested in the games aspects and not only on the novelty. During the tests many children asked to do the activities several times and not only once as planned. Most of them showed interest in the Gum after the tests. They asked to play again when all the accessories, Gum and computer were packed and the tester was ready to leave from the participant’s home. Some weeks after the test, the majority of parents mentioned that their children continued asking for the Gum, and some of the kids named their own food after the Gum’s food.

In the second test the attachment of the participant increased with time. As the days passed the boy showed more affection and had more interaction with the toy. However, it is possible that his reactions towards the toy and him increasing physical activity were influenced by the fact of knowing that he was testing the toy.

Preliminary tests which were limited in time and number of participants can not give final conclusions, but it was overall observed that children did understand and appreciate the key elements of the toy; that the toy motivates the child to play with it; and that playing with it led to more physically active behavior. Some indication was found that this continues in the mid-long term: even when not responding to the toys signals immediately, the test child did feel responsible to keep the Gum happy and therefore engage in Physical activity in the course of the day.

8 Conclusions

The project indicates that interactive toys can be an effective tool to reduce sedentary behaviour and motivate the increase of physical activity.
The key elements used in this toy were useful to get the children engaged in the different game aspects and due to their engagement change their physical activity behaviour. Being socially active with the toy was achieved, and at the same time, the toy allowed the increase of physical activity through social interaction, since children were more willing to play.

Some concern may arise about converse health implications to children with eating disorders. Thought food is part of the narrative, the toy/play does not encourage dieting or reducing food intake in any way; instead, it focuses on burning calories through physical play.

The project suggests that toys can to some extent compete with television and computer games and seduce children to leave these behind to engage in more physical and social play behaviour.

For the moment this is a concept that opens a possible research line, if its development is continued it will probably make a product with high play value. The next step could be to produce a large series of prototypes to use with children in a longer term and to integrate more social games.

To come to more definitive conclusions a large scale test is necessary to verify the findings so far and measure caloric expense through use of the day.

9 REFERENCES