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ORIGINAL ARTICLE

Get up and move: an interactive cuddly toy that stimulates physical activity

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Abstract Health experts are worried about the increase in the number of overweight children and the decrease in activity levels among this age group. This project explores the possibilities of using interactive toys and social interaction in encouraging children to become more physically active. To arrive at the final concept, research was conducted into the factors that encourage and discourage physically active play in children. Based on that knowledge, four key elements were used to develop the product: fantasy, social interaction, surmounting physical and cultural barriers and inspirational factors. The project resulted in a cuddly toy that stimulates young children aged 4–8 to care for it through their own physical actions. First limited tests indicated that children appreciated and understood the toys' key elements, and suggest that it could be possible to use interactive toys and social interaction to change behaviour with regard to physical activity.

Keywords Interactive toy · Physical activity · Sedentary behaviour · Social interaction · Fantasy · Obesity · Health care

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1 Introduction

Recent studies show a significant increase in the number of overweight children and adolescents in the last decade, and at the same time indicate that children's physical activity (PA) and physical performance have declined [1]. The majority of children in the Netherlands do not meet exercise standards[1] and exceed the American Academy of Paediatrics' recommendation for sedentary activities.[2] Some reports highlight the role of digital technologies (television, videogames and computers) in shifting children's play into sedentary experiences [2–4]. However, media have recently been used to increase PA. Physical interactive games (PIGs) aim to promote the positive physical aspects of computer gaming. In addition, they facilitate social interaction and bonding. Well-known successful PIGs include Nintendo Wii®, DanceDanceRevolution® and Xerbike®.

Besides these well-known games, other products less widely commercialised aim to stimulate PA by giving the child a reward. Fizzies by Futurelab (http://www.futurelab.co.uk) is a wrist-worn digital pet whose health and well-being depend on its owner's physical actions, and ME2, by Irwin Toy (http://www.irwintoy.com) is a pedometer device used to gain access to an online gaming experience.

The above examples show the growing interest in the use of electronic toys to prevent and treat obesity in young people. They build on the attractiveness of digital games and either require PA during the interaction or offer benefits that can only be achieved through PA in an additional part of the game.

[1] 60 min of daily physical activity.

[2] Maximum of 2 h daily.

These games strive for a general increase in PA through the gameplay. Most of them rely on the enthusiasm of the child for videogames, and when they lead the player away from the screen, ultimately make the player come back to the screen. They do not provide the stimulus to play at the time when it is most necessary: after prolonged periods of sedentary behaviour.

In the project presented in this paper, the intention was not only to increase PA, but to do so independently of a screen-based play concept and at times when children showed prolonged periods of sedentary behaviour. The objective was to develop an electronic/interactive toy that measures children's inactive time and motivates them, when needed, to reduce their sedentary behaviour and increase their PA (for a detailed description of the project, see [5]).

2 Research

Research methods comprised literature research, interviews and generative sessions. There is vast documentation regarding (in)activity in children. Complementary interviews and generative sessions were carried out to gain empathy with the users. Information from 19 children living in the Netherlands, aged between 4 and 8, with diverse socio-economic backgrounds, was collected by interviewing 13 parents in an open interview structure. Generative activities were carried out with their children. A 2-h generative session was held with nine children with the goal of getting an insight into what children like to do at home and what motivates them to play outside and stop using media.

The following section describes the main results of the research.

2.1 Sedentary behaviour and PA in children: the I-change model

Moving from sedentarism to activity requires a behaviour change. A behavioural change model was therefore chosen to identify the motivational mechanism and the procedures necessary to promote change from sedentary behaviour to active behaviour. The integral model of change (Fig. 1), or I-change model [6, 7], was chosen, as this is the behaviour change model most widely used in the Netherlands and has been used for similar projects by the TNO (Dutch Organization for applied Sciences).

The research outcomes are presented within the context of the various factors of this model. All factors of the model related to sedentary behaviour and PA are relevant, but only those factors that turned out to influence the design decisions are described below; we will not explain information factors, awareness factors or ability factors (see Table 1).

2.2 Technology and children

Children are strongly attracted to technological products such as TV and computer games and use them on a daily basis. These are often barriers to PA, but some of their aspects can be used to stimulate PA.

Crawford [8] 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 people can overcome social restrictions through fantasy. Malone [9] estimates that of all the features of a computer game, fantasy is the most important feature that can be usefully included in other user applications. In his studies, he explains that there are four main factors that motivate the use of specific video games:

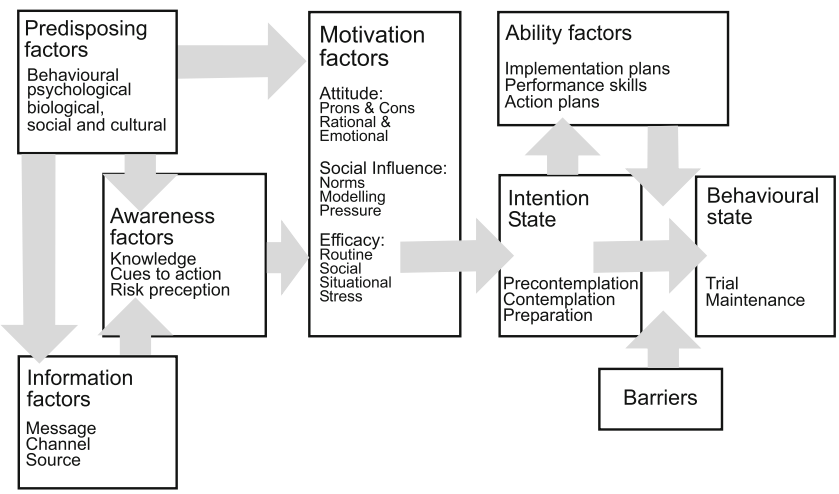

Fig. 1 The I-change model [7] shows which factors contribute to behaviour change

Table 1 Research outcomes related to each behaviour change factor

Predisposing factors	*Gender*: girls more inclined to be overweight and take less PA [12]; steeper declines in PA during adolescence [13]
	Sociodemographic: low income, ethnic minority, single parent and overweight parent are related to TV viewing and children being overweight [2, 14, 15]
Motivation factors	*Fun*: could be the most important determinant [16]; children participate in sport when they enjoy it
	Social influence: parental support and family's influence is consistently conducive to greater amounts of physical activity [16–18]; friends are a second important stimulator to play outdoors, or change from a media use activity to another type of play
Intention state	Related to parent's intention to motivate/take their children outside or to a sports facility
Barriers	*Environmental*: dog waste, high traffic, high rise buildings [15], canals, distance to playground or sports facility
	Cultural: some parents think that older children can be of negative influence [14]
	Television and computer: 53% of Dutch children give TV or the computer as the main reason for not playing outside [19]; research [3, 4, 20] shows that television viewing and electronic game/computer use are associated with adiposity
Behavioural state	*Trial phase*: people start increasing their PA
	Maintenance: after 6 months of behaviour change

fantasy, curiosity, control and challenge. Games appeal by evoking the user's curiosity. Environments can evoke curiosity by being novel and surprising. Sounds and images are usually used to enhance curiosity [8, 10, 11] and contribute to the player's immersion in the game and concentration by providing sensory "proof" of the game's reality. The challenge depends on the relationship between the player's abilities and the complexity of the task. Personal meaningful goals with uncertain outcomes enhance challenge.

Druin, Crawford and Sweeters mention the importance of allowing social interaction. Druin [10] explains that children naturally want to be with each other, Crawford [8] and Sweeters [11] mention that people play games to interact with other people, regardless of the task, and will even play games together that they do not like or even when they do not like games at all.

3 Concept development

3.1 Design objectives

Following the research phase, the following design objectives were established:

- make children move away from the source of sedentarism, and not return to it afterwards,
- reduce sedentary activities to a maximum of 2 h daily, in accordance with the American Academy of Paediatrics,
- provide a minimum of 60 min of PA daily, in accordance with activity guidelines,
- stimulate indoor and outdoor play.

3.2 Key elements considered for the design

The research provided a number of key elements to apply to the product.

- Surmounting environmental and cultural barriers:
  Since many children cannot freely play outdoors, their natural play area (inside their home) could be adapted to allow more PA. Even if the solution were focused on inside play, play should provide a motivation factor to be used outside as well.
- Social interaction as a motivational factor:
  Parents and/or friends play a major role in a child's behaviour and children naturally want to play with each other.
- Use of fantasy as play type:
  Children often play fantasy games, and fantasy has proven to be effective in attracting them to play video games or watch television. In this project, by contrast, fantasy was used to attract children towards physical play and away from television and computers.
- Use of curiosity, control and challenge to support the fantasy.
  Other elements that have proven beneficial to motivation in video games were used to support the fantasy.

4 Final design

The final design consists of a cuddly toy with electronic interaction capacities, called "Gum". The central fantasy of the concept is that a Gum is a 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 Gum can pronounce words and emit sounds to ask for things or to show its mood. It can also light up its ears and stomach and vibrate to communicate. Figure 2 gives an overview of its functions. Along with the Gum, a child receives a set of objects (to enable the child to feed and play with the Gum), a pouch to carry the Gum, a short story to learn about the Gums, a parents' guide and a charger.

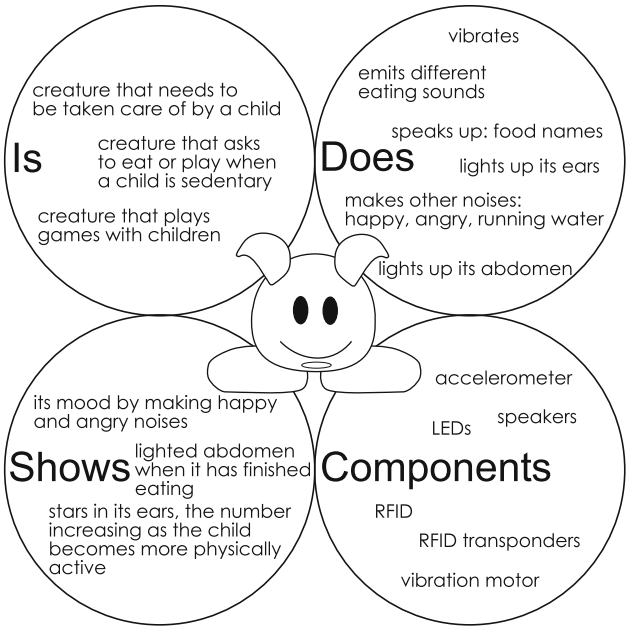

Fig. 2 Gum's activities and components

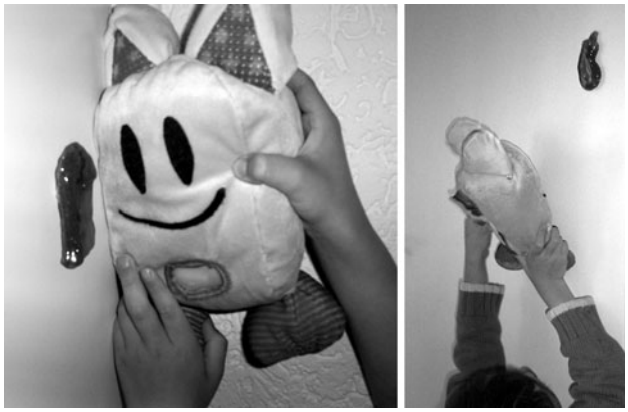

Fig. 3 Gum sensing a food object

4.1 Narrative

A Gum is healthy and happy when it has at least a certain minimal amount of daily PA. To sense the child's PA, the Gum is placed in a special pocket, which is attached to the child's waist.

As the Gum gets healthier, lighted stars will appear in its ears, until it reaches a maximum health state. To increase the number of stars, the child needs to progressively increase and later on maintain its PA level. This takes several days, and up to a month in the last levels. The goal is that at the end of the 6 months (maintenance state), a child achieves several bouts of activity, accumulating 60 min of moderate to intense PA a day.

Food items for the Gum (objects with an RFID tag) have to be placed in different parts of the house, far away from each other. Some places are suggested in the Gum's story while others have to be selected by the child. 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 around the house to where the food is placed (see Fig. 3). Gums make different noises depending on the food they are asking for or the food they are eating. The type of food a Gum eats changes over time. This indicates to the child the level of evolution between stars (see Fig. 4). Besides eating, Gum activities include going to the toilet, taking a shower or playing with toys and/or other Gums.

Gums 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 the Gum's level), and dim when the child does not. The Gum can become angry if it has not moved enough and happy if it has.

When the Gum is not in use, it sleeps in its bed (charger). When the child takes the Gum, the toy will sense the movement and automatically turn on, making a "good morning" noise. If the child is not carrying the Gum around, it will shut off after 5 min of absolute non-movement, meaning that it is sleeping.

4.2 Social games with the toy

In addition to the central story of nurturing and feeding, the Gum's behaviour includes games. Children can start these games or a Gum can ask to play a game, instead of eating, if it senses that the child has been inactive for a long period. These games are intended to stimulate social play with other children, who at the same time encourage the use of the toy. The games are intended to be open-ended so the child can freely choose what to play.

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 a number of times (depending on the level) the Gum will blink its ears and say "yuhoo".

The simplicity of this type of interaction makes it possible to play many games. One example is running away from the ball/spider: the child runs to escape from the ball/spider that the parent or friend is carrying, and when the parent/friend has touched the Gum a number of times, he/she wins. If another child has a Gum, more games can be played.

One game that can only be played with two Gums and a set of toy eggs is the following: children race 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 child will hear either a happy or an angry

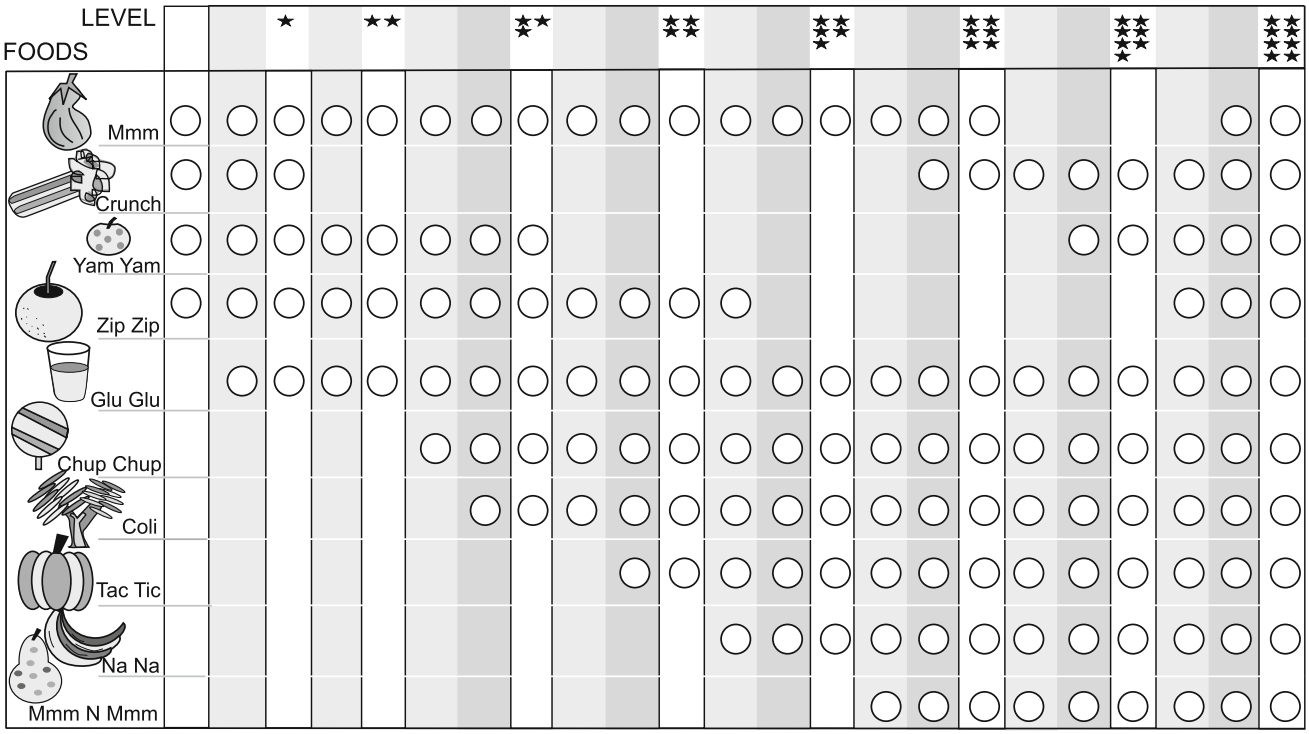

Fig. 4 Relationship between Gum food and stars

bird sound when touching an egg with the Gum. The first Gum to make four birds happy wins. The Gum who wins vibrates and says "yuhoo".

4.3 Gums compared to other interactive toys

In some respects, Gum is similar to a Tamagotchi (http://www.tamagotchi.com), a Furby (http://www.mimitchi.com/html/furby.htm) and/or a Fizzie (http://www.futurelab.co.uk). Some Tamagotchis and Fizzies are personal digital interactive toys that stimulate children to exercise, and Furbies (http://www.adoptafurby.com) are interactive pets that encourage children to talk to them.

Gums, however, take this concept one step further, as they specifically react to prolonged periods of sedentarism, try to literally move children away from the sources of sedentarism (e.g. TV, computer screen or maybe even reading a book), they promote PA both inside and outside the house and they propose diverse activities and games.

4.4 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 toys, especially to stuffed puppets. A Gum is meant to be a special partner, almost like a pet. The chosen activities are similar to living creatures' activities. The accompanying story helps children become immersed in the fantasy.

Social interaction. Different methods are used to stimulate social interaction. A child will want to show their friends how they have helped their Gum to become healthier, they will show the number of stars in the ears and friends can make comparisons. The games encourage social play. The kissing eggs game is only possible when a child is with someone else. Playing with the ball and the Gum is more exciting if many children are playing.

Parents will have a guide to the correspondences between the level of the Gum and the quantity of PA required, so they can be aware of their child's PA.

Inspirational factors. The game was inspired by certain video game qualities: goal, challenge, curiosity and control. These factors support the fantasy. In this case the main goal is clear: make the Gum healthier and happier by being active. The challenge increases as time goes by. Curiosity is engaged, as the child is curious as to what will happen: when is the Gum talking, when are the stars going to appear? Curiosity is supported by the sounds, vibration and lights. The child can control some actions by ignoring the Gum or by asking the Gum to eat or play.

Surmounting cultural and environmental barriers. These barriers are surmounted by allowing the child to use the Gum and engage in PA at home, since many children

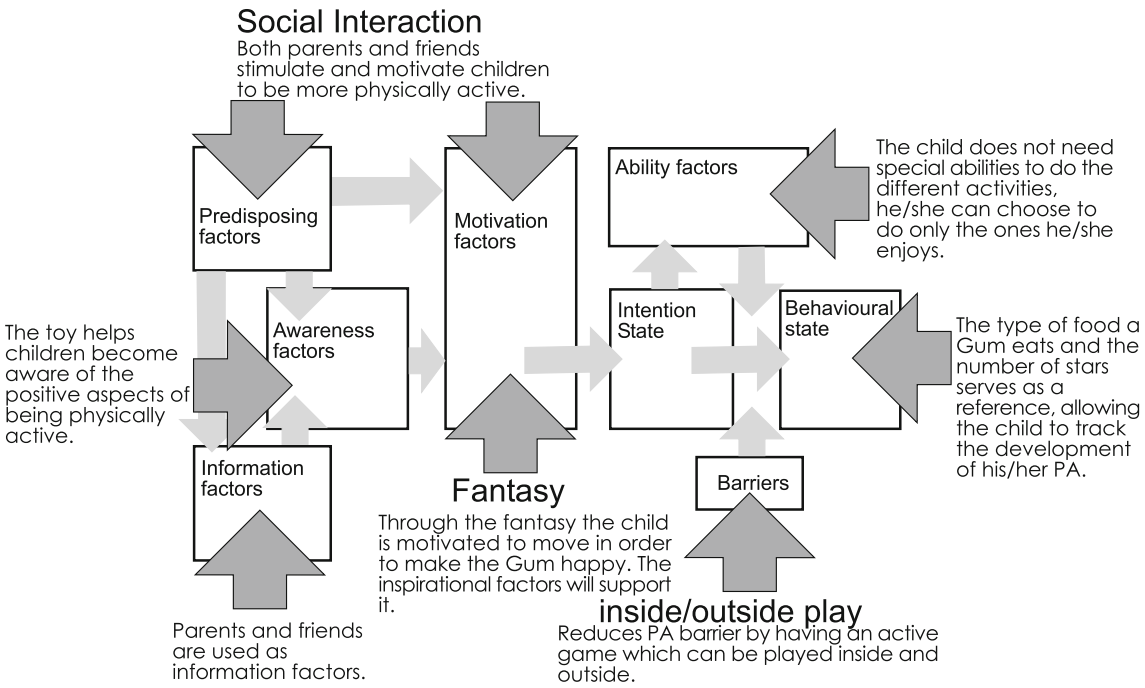

Fig. 5 Key elements used to influence behaviour change in children

cannot play freely outdoors. However, the game is not restricted to indoor play and can be used outside. Figure 5 shows how these elements could affect behavioural change.

5 Testing

For technical reasons, it was not possible to produce a fully working prototype. Two pairs of prototypes connected to a PC were made to test the concept. The final design is intended to function without an external computer.

5.1 Technology

In order to reduce sedentary behaviour when needed, it was necessary to measure it. This is achieved by using a two-axis accelerometer to measure (in)activity. RFID technology was used to enable the toy to react to different objects. The data was processed by Max/MSP (http://www.cycling74.com), which also controlled the sounds, vibration and/or lights, creating the toy's behaviour.

5.2 Motion parameters

A two-axis accelerometer was used to measure motion. Depending on the intensity of movement, one of the timers incorporated in the program starts functioning. Three timers were incorporated: a sedentary state timer, a normal activity timer and a moderate/active activity timer. Only one timer functions at a time. The intensity of the movement required to activate a timer was based on Sirard's [12] classification of the intensity of activities (see Table 2).

To calculate the thresholds of movement, the puppet was attached to two children's waists. They were asked to perform different activities several times. Figure 6 shows the amplitude levels for different activities during a period of approximately 3.5 min. Values on the *x*-axis show the time in seconds, while the *y*-axis shows the intensity of the activity. We do not know the exact units given by the accelerometer, but this is not a problem since we only needed them to compare activities on the same scale. Values between 0 and 50 correspond to sedentary activities (watching TV and slow walk), while between 50 and 100 are light activities (normal walk) and over 100 moderate/active (jog, run, jump).

Table 2 Relationship between Sirard's classification and timers in the prototypes

Sirard's classification	Timers in prototype
Sit and sit and play: sedentary activities	Sedentary activities
Slow: light activity such as walking	Light/normal activities
Fast walk: moderate activity Jog: vigorous activity	Moderate/active activities

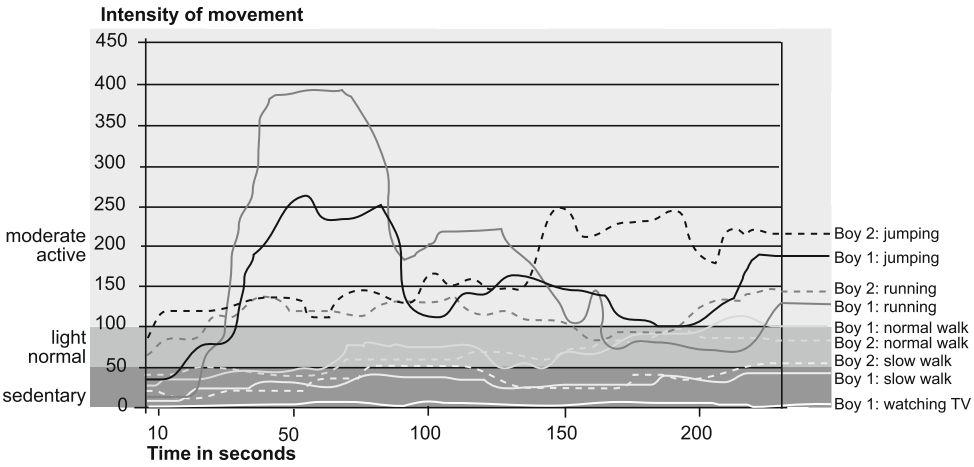

Fig. 6 Activity amplitude levels during various activities

5.3 Test setup

Testing of the prototype was divided into two different test setups: short and long. The first setup consisted of a series of tests with eleven children aged 4–8, lasting 2 h each. This group of children had different backgrounds, since the toy is meant for a general audience and not specifically for an obese group. For technical reasons the tests were conducted with a Gum attached to a computer with a long wire. The second set-up consisted of one longer test involving 1–7-year-old boy, 1 h per day for 10 days, with a wireless Gum. The boy can be classified as imaginative and not very active. He prefers to watch television and engage in calm activities rather than play outside.

Before the tests were conducted, the story and the parents' guide were sent to the families' homes. The main purpose of the first test was to observe the reaction of the children and parents to the overall concept and their understanding and appreciation of the key elements. Various parts of the interaction were tested: feeding, ball game and egg 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 such a short time frame. The second test served to observe those elements that required more prolonged use. For both types of tests, the short exposure time was due to the restriction of having to use a computer to communicate with the Gum. It was not possible to have a tester with the computer following the child, nor to leave the computer with the parents.

Both tests had several limitations. A within-group design would have been useful to compare the child's behaviour before/during/after exposure, but this was not possible given the small-scale, explorative nature of the study. Whenever possible, however, observations and findings from children's sessions were verified through interviews with the parents.

In addition, 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.

6 Test results

The results of the tests are presented here in the context of the key elements used for the design, as defined in chapter 3.

Fantasy: it could be observed that children believed in the creature's reality. After reading the story they all remembered it, and most parents mentioned that their children were impatient to meet the Gum. Many children, especially girls, showed signs of affection towards 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 it. He demonstrated his love for it 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. Parents participated with children in placing the food objects and by reading the story together.

The social element proved to stimulate the children to be physically active in a different and more direct way than the Gum alone. The more children there were, the longer they played each game.

With the spider/ball game, children engaged in active PA for more than 30 min, especially when more than two children participated in the game. Figure 7 shows the activity amplitude levels during different activities while wearing the Gum over a period of 10 min.

Curiosity: it was observed that the sounds and vibration helped the children become immersed in the fantasy. Children responded to the Gum talking and wondered what

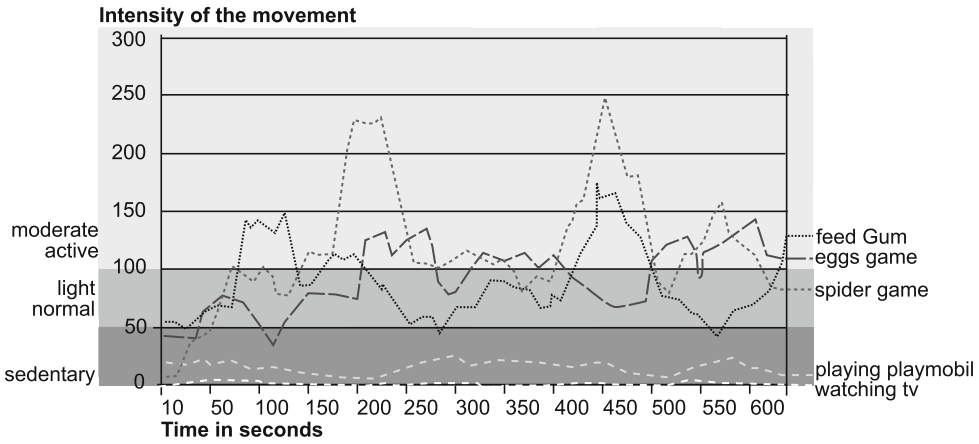

Fig. 7 Activity amplitude levels during various activities while wearing the Gum

it would ask next. Most children found the sounds funny and smiled or laughed after hearing them.

Control: during the second test, the tester indicated a wish to have control of the Gum and the game. He often made the Gum eat before it asked for food. On some occasions, while watching television, he ignored the Gum once or twice and fed him when he thought that the TV programme was almost over.

Goal: the boy in the long test showed understanding of the goal of obtaining many stars through PA. On several occasions, he mentioned wanting to be active in order to have a Gum that had many stars and ate more food.

Reducing sedentary behaviour: it was observed that the puppet made it possible to reduce sedentary behaviour and increase PA. However, PA is not necessarily prolonged after interacting with the toy. During the second test the boy paid attention to the Gum when it asked for something. However, when the Gum asked for something during a television programme he would ask it "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 ignored the Gum, but when the Gum got angry, he was very surprised, felt bad about it and got up and fed the Gum.

Increase PA: it was observed that children could be very active while playing with the Gum and that wanting to make the Gum happy could increase PA. Children were active when playing the different games, especially the spider game. The egg game and feeding the Gum were observed to be moderately active activities (see Fig. 6).

During the second test, the child increased his PA 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 (see Fig. 8).

Most parents said that they appreciated the toy and said they thought that their children would be motivated to move more thanks to the star system.

7 Discussion

As the results show, both children and parents in general showed a good understanding and appreciation of all key elements of the design. Some outcomes of the tests are ambiguous and require interpretation.

Fantasy and curiosity: it is possible that the enthusiasm the children showed towards the toy was a first reaction to a new toy or was influenced by wanting to satisfy the tester. However, some indications suggest that children were interested in the game aspects and not only reacted to 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. Some weeks after the test, the majority of parents mentioned that their children continued asking for the Gum, and some of the children named their own food after the Gum's food.

Some concern may arise about negative effects on children with eating disorders. Though food is part of the narrative, the toy/play does not encourage dieting, reducing or increasing food intake in any way; however, it may be worth considering a different fantasy for the future.

Fig. 8 Being happy when the first star appeared

In the long 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 his increasing PA were influenced by knowing that he was testing the toy. Long-term effects must be determined in the future. It would be useful to determine the profiles of children for whom the Gum is successful.

Social interaction: it can be argued that children do not need interactive toys to engage in social play with peers, and that many other games stimulate PA through social play. However, in this case the social element was used to stimulate the use of the toy and not vice versa. Parents also play a key role in both social interaction and health related behaviour for young children.

Control and goal: users have the option of ignoring the Gum's signals and continuing their sedentary behaviour. The Gum will repeat its signals every 5 min and eventually become angry. This enables children to delay PA until a sedentary activity (e.g. watching TV) is finished; this was indeed observed in the long test. It is believed that this is a positive feature of the toy. Children need to bond with the Gum and use it over a long period to achieve a higher PA level in their daily lives. If the toy dictated immediate actions, this could annoy the child to a point at which they stopped using it. The effectiveness must be measured in the future.

Reducing sedentary behaviour: it can be argued that when the children finally do react to the toy's signals, this is at a moment when they would have stopped sedentary behaviour anyway. From the observations made, it is judged that the child did feel responsible for the Gum's well-being and did experience an extra stimulus to become active. For the moment, the toy cannot effectively detect the type of movement the child is making. A broader motion sensor study needs to be carried out, to allow the Gum to recognise specific movement gestures, and for example perceive if the child is moving the toy with its hand instead of wearing it at its waist.

Increasing PA: the measurements of activity levels for various play types (Fig. 6) show that feeding the Gum is only a moderately active type of play. Clearly, as children need to be motivated to start an activity when they are sedentary, it is easier to start with play at a moderate activity level. For the health objective of the project, it would be desirable for this to develop into active play. In this respect, the toy brought welcome improvements, for instance by promoting social (chasing) games, with which high PA levels were achieved.

It is not possible to draw final conclusions from preliminary tests limited in time and number of participants, but overall it was observed that children understand and appreciate the key elements of the toy; that the toy motivates the child to play with it and that playing with it leads to more physically active behaviour, especially in a context of social play.

To obtain evidence concerning the enduring effects of the toy it would be necessary to evaluate the effects over a longer period (for instance >6 month). It is possible that children and/or parents would become annoyed about the noise or the repetitive activities related to the toy and would stop using it. In addition, it would be useful to test a control group with similar products, to measure the toy's effectiveness over others.

8 Conclusions

The project indicates that interactive toys could be an effective means of reducing sedentary behaviour and motivating an increase in PA.

The key elements used in this toy were effective in engaging the children in the different game aspects. In turn, this engagement led to a change in their PA, at least in the short term.

The project outcomes suggest that toys can to some extent compete with television and computer games and encourage children to engage in more physical and social play behaviour. In order to draw more definitive conclusions, it will be necessary to conduct a larger scale longitudinal test, to verify the findings so far and measure consumption of calories through use of the toy in the long term. The next step could be to improve the toy based on the preliminary findings, e.g. integrate games with increasing activity levels and active social games, and evaluate the effects over long periods of time.

In its present state, this is a concept that builds upon the qualities of other toys by encouraging PA at specific moments and using key elements of games and narratives that appeal to children in order to create valuable play, both in terms of fun and PA. This project opens the way to new research and design efforts aimed at improving children's health through highly active social play over prolonged periods.

References

1. Brettschneider WD, Naul R (2004) Study on young people's lifestyles and sedentariness and the role of sport in the context of education and as a means of restoring the balance. European Commission report

2. Van den Boogaard C, de Vries S, Simons M, Jongert M (2007) Bewegen met computergames. TNO Prevention and Healthcare, The Netherlands
3. Hesketh K, Wake M, Graham M, Waters E (2007) Stability of television viewing and electronic game/computer use in a prospective cohort study of Australian children: relationship with body mass index. Int J Behav Nutr Phys Act 4:60
4. Vandewater EA, Shim M, Caplovitz AG (2004) Linking obesity and activity level with children's television and video game use. J Adolesc 27(1):71–85
5. Leal Penados A (2008) Get up and move: development of a sedentary measurement tool that stimulates physical activity. MSc Thesis, Delft University of Technology. http://www.geocities.com/lealpenados/gumreport.html (Unpublished)
6. Schermers P, Jongert MWA, de Vries S (2009) Is de Healthcheck effectief als vorm van beweegstimulering bij VMBO-leerlingen? TNO Kwaliteit van Leven. Preventie en Zorg
7. De Vries H, Mudde A, Leijs I, Charlton A, Vartianen E, Buis G (2003) The European Smoking prevention Framework Approach (EFSA): an example of integral prevention. Health Educ Res 18:611–626
8. Crawford C (1997) The art of computer game design. Washington State University. REV.5.27.97 http://www.vancouver.wsu.edu/fac/peabody/game-book/Chapter1.html
9. Malone TW (1981) Heuristics for designing enjoyable user interfaces. Lessons from computer games. Xerox Palo Alto Research Center, Association for Computing Machinery, Palo Alto
10. Druin A, Bederson B, Boltman A, Miura A, Knotts D, Collan I (1997) Children as our technology design partners. In: Druin A, The design of children's technology. Morgan Kaufmann, San Francisco
11. Sweeters P, Wyeth P (2005) Game flow: a model for evaluating player enjoyment in games. The University of Queensland, St Lucia, Australia. ACM Comput Entertain 3(3)
12. Sirard J, Trost S, Pfeiffer K, Dowda M, Pate R (2005) Calibration and evaluation of an objective measure of physical activity in preschool children. J Phys Act 3:324–336
13. Evenson K, Scott M, Cohen D, Voorhees C (2007) Girls' perception of neighbourhood factors on physical activity, sedentary behaviour, and BMI. Obesity 15(2):430–445
14. Boere-Boonekamp M, L'Hoir M, Beltman M, Bruil J, Dijkstra N, Engelberts A (2008) Overgewicht en obesitas bij jonge kinderen (0-4 jaar): gedrag en opvattingen van ouders. Ned Tijdschr Geneeskd 152(6):324–330
15. De Vries S, Bakker I, Van Machelen W, Hopman-Rock M (2007) Determinants of activity-friendly neighbourhoods for children: results from the space study. Am J Health Prevent 21:312–316
16. DiLorenzo T, Stucky-Ropp R, Van der Wal J, Gotham H (1998) Determinants of exercise among children. II. A longitudinal analysis. Prev Med 27:470–477
17. Golan M, Weizman A, Apter A, Fainaru M (1998) Parents as the exclusive agents of change in the treatment of childhood obesity. Am J Clin Nutr 67:1130–1135
18. Zabinski M, Saelens B, Stein R, Hayden-Wade H, Wilfley E (2003) Overweight children's barriers to and support for physical activity. Obesity Res 11(2) pp 238–246
19. Jantje Beton (2003) http://www.sp.nl/nieuws/nwsoverz/div/030729jantjebeton.stm
20. Janz KF, Levy SM, Burns TL, Torner JC, Willing MC, Warren JJ (2002) Fatness, physical activity, and television viewing in children during the adiposity rebound period: the Iowa bone development study. Prev Med 35(6):563–571