AIRPlay: Towards a 'Breathgiving' Approach

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Abstract. Children with exercise-induced asthma face several challenges in their daily life, which can improve by proper self-management practices. AIRplay combines biomedical sensing with gamified environments to improve physical conditioning and self-management of asthma among children aged 7 to 9 years old. The goal is to develop a proof-of-concept of coaching application that monitors physical activity of a young asthma patient, provide feedback based on this activity data, and integrates this application with an interactive playground to improve fitness. We discuss three areas where we can improve the current management of asthma among children based on literature and interviews with health care professionals. We present the coaching application and the interactive playground game, followed by a discussion where we discuss the current proof-of-concept using the Persuasive Design Model (PSD). We also foresee some challenges for future development and research.

Keywords: Behavior Change Support Systems, asthma, gamification, playgrounds, coaching, self-management .

1 Introduction

Asthma is the most common chronic disease in childhood. In the Netherlands the number of people with asthma is well over 443.000 and is steadily increasing [1]. Recent estimates show that about 5% of children (4-11 years old) in the Netherlands have to cope with asthma [2]. Asthma is an inflammatory disease of the airways of the lungs, characterized by variable and recurring symptoms, including episodes of wheezing, coughing, chest tightness, and shortness of breath. Exercise-induced asthma (EIA) affects 70-90% of the asthmatic children [3]. EIA can deter children from participating in regular physical activity and eventually lead to dropping out of play and sports [4]. Many environmental factors have been associated with asthma's development and exacerbation, such as house dust mite, air pollution, tobacco smoke, and perfume. However, the extent to which each one of these factors induces exacerbation is highly personal [4]. Children must learn about how to anticipate triggers/circumstances that enhance their EIA. Medication adherence, physical exercising and education –aimed at improving the ability of children to control their asthma themselves– are crucial for successful asthma control.

From interviews with medical experts (three pediatricians with experience in the care of asthmatic patients) and from the literature we identified three main areas where technology could be used to improve the current management of asthma among children. The informal semi-structured interviews were performed in several iterations, three meetings were accompanied with presentations to explain the problem areas, care challenges, and opportunities for technological enhanced asthmatic care. First, there is the importance of the physical conditioning of the children. Systematic- and meta-analysis of the literature showed no consensus whether children with asthma are differently engaged in physical activity than children without asthma [5, 6]. However, it is generally accepted that maintaining active lifestyle is of utmost importance for management of asthma symptoms, and therefore children with controlled asthma must be encouraged to engage in physical activity [7,8]. Children with uncontrolled asthma are less fit. Uncontrolled asthma is associated with less time spent in intensive physical activity, resulting in reduced fitness [9]. As a consequence, compared to their healthy peers children with asthma are more likely to be overweight, bringing additional health related problems [6]. Children with asthma report experiencing limitations related to various activities that involve a physical effort (such as playing outside, carrying heavy weights or swimming) [4]. Technology-based interventions might support children in achieving the recommended levels of physical activity at their own pace, thereby increasing their asthma control.

A second area is the use and adherence to medication. Adherence to medication preventing asthma symptoms has been associated with better disease control. Non- or suboptimal adherence is associated with poorer disease control and increase in asthma morbidity and mortality [10].

Studies examining adherence rates with preventive medication by asthmatic children have reported average adherence rates of 50% to 77% [11]. Learning the best practices on how and when to take medication is a crucial step to improve self-management of asthma, which can be supported by technology.

The third area identified in which technology can support self-management of asthma relates to the social, emotional, and mental aspects. Children with asthma do feel they are different (less popular) and lonely because of their disease and the medication they have to take. They experience limitations during (sport) activities with peers and are being bullied, left out and not believed by their peers [4]. Technology might support social integration of children with asthma by enabling initiatives that require cooperation between children within the same group.

In childhood asthma there is critically low treatment adherence and there is treatment failure which is resulting in high costs and low Quality of Life (QoL). Self-management is needed for optimal asthma control (and life-long health consumption). Current healthcare is not sufficiently supporting children in acquiring self-management skills because of lack of support by health professionals and a lack of insight among parents and children.

Initial studies on technology-based interventions to promote self-management of asthma focusing on education and medication adherence among the pediatric population have suggested promising results [12]. Studies indicate that gamification might improve the self-management of chronic illnesses, such as diabetes [13,14]. However, engagement with the technology, which often asks for additional activities from the user, diminishes over time. The challenge is thus to keep the user engaged with the system in the long run. The combination of gamification and virtual coaching, is expected to have a positive impact on the patient's self-management skills, knowledge, and adherence to their health care regime.

2 The AIRplay Concept

The AIRplay project aims to improve the physical conditioning of children with asthma (7-9 years old) by combining mobile monitoring of daily physical activity with behavior change strategies in gamification elements. That is to say, that we focus on the identified problem areas of physical conditioning and social/emotional aspects, and at least for now not focus on medication adherence. This in short is the context of our AIRplay project: a collaboration between healthcare professionals (Medisch Spectrum Twente and Ziekenhuisgroep Twente) and researchers from the University of Twente in the fields of biomedical signals and human computer interaction.

Pervasive technology makes it possible to track physical activity, using affordable sensors that can be worn throughout the user's daily life. In combination with tablets and other mobile devices that provide visual feedback, this allows for improving insight into children's own behavior. In order to persuade children to change their behavior, improving their insight and also encouraging physical activity, we incorporate several coaching and gamification elements into a combination of pervasive technologies.

We are currently working on an implementation of these technologies, consisting of three elements 1) a simple wearable physical activity sensor, 2) a tablet application, and 3) an interactive playground. With this combination we go beyond the screen, unlike other exertion games we attempt to change behavior beyond the game play itself (cf [15]), and target the three areas identified in interviews and the literature: the social, emotional, and mental aspects of the children; their fitness; and their adherence to and use of medication.

For one, in this project we choose to both address healthy children and children with asthma together, in a similar manner. We view that children with asthma should not be stigmatized but should be included in social play behavior (according to their capabilities), and preferably be challenged to increase their amount of play with others, which in turn can help to improve their emotional and mental aspects.

We also target improvement of the fitness of the children. Each child will be provided with a personal daily physical activity goal, in the form of a to be attained number of steps for that day. The target number of steps will be tailored based on their capabilities, and the amount of steps counted by the sensor is send to the tablet application.

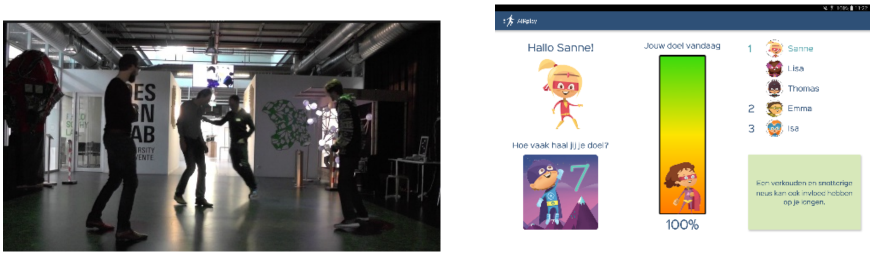

Fig. 1. On the left: the playground being tested by several adults at our lab. On the right: the app with a personal goal (middle), the attainment of goals (bottom left), a ranking system (top right), and a tip of the day (bottom right)

The application will show which percentage of their goal they reached, and in this way tries to stimulate to move more and increase their *fitness*. A ranking between children will be made based on this percentage. Another element we are incorporating, is to reward children with additional abilities in another game, that is physically present in their world. This game is played on an *interactive playground* that could be placed at a school. This playground, consists of an interactive floor projection of about 5 by 5 meter, that responds to players positions as measured by top-down Kinects, see Figure 1. This system was provided to us and allows users to walk in and play without additional calibration or devices, for more detail on the system we refer to [16].

The application will also provide useful information and tips regarding the medication, but only for the children with asthma. This could increase the awareness about their medication, and in this way also help to improve *adherence and use of medication.*

3 The Playground Game

We created a game on the playground where children have to use their projected avatar on the floor to either tag an opponent or to catch an opponent, see Figure 2 for a depiction of the game mechanics.

There is a 'safe house' that is located in a corner, and switches to another corner every 10 seconds. This 'safe house' can be used to take a break from the game, players cannot get caught or tagged whilst inside, this might allow a child (especially those useful for those with asthma) to take a deep breath or even take medication, if necessary. In order to materialize reaching their daily physical activity goals, children are rewarded by unlocking additional levels in the playground game, for instance a level where both teams are able to catch each other.

3.1 Playground Play Sessions

About 80 children played with the playground game in four iterations. In total in the first and second iteration combined about 60 children (6-12 years old) participated as part of field trip of their primary school to the university premises. In the first iteration

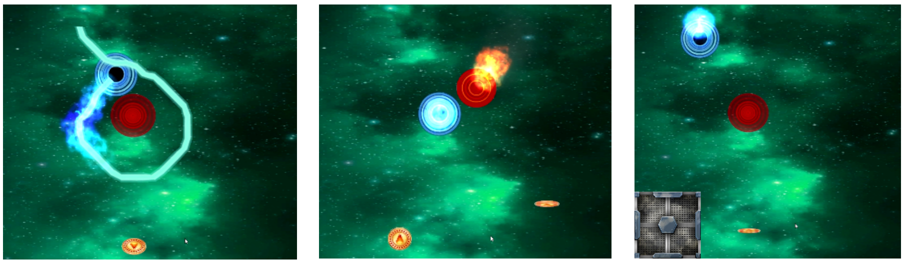

Fig. 2. On the left, a blue player catching (surrounding) a red player. In the middle, a red player about to tag a blue player, after collecting two coins (visualized by being on fire). On the right, a safe house located in the bottom left corner where a player can take short time-out.

children were slightly older (10-12 years old) than during the second iteration (6-10 years old). The third iteration involved 7 healthy children (7-9 years old) and the fourth and last iteration included 8 children with asthma (7-12 years old), playing in the playground. During the four sessions children showed evidence of physical fatigue, as could be witnessed by their red faces and fast breathing rate. The children did have trouble understanding the game, and additional explanation was given during the games. Nonetheless, children very much liked to play in the playground, as they often asked us to play again, and as was witnessed by the remarks made during the game.

4 Discussion

Although we did not explicitly start with using a framework like Persuasive Systems Design [17], having several years of experience in persuasive technology design, we can still clearly see that the system design embeds several principles of the PSD framework. Here we use the PSD in a more post-hoc formative evaluation manner, and focus on the persuasive design features of the framework. Many principles are already incorporated to some extend but other principles of the framework provide insightful suggestions. We mention some of these below.

For the *Primary Task Support* principles it is clear that we used *reduction, tailoring, personalization, self-monitoring, and rehearsal.* Regarding the principle of tunneling, we do not yet specify how the activity goals will be changed over time, and how the hints will be used from a more holistic point of view about medication intake. Furthermore, steering behavior in the playground –changing in-game behavior in a more directed way with the introduction of new game elements– could also be used as an interesting tunneling approach to further improve physical activity [18]. Also, *simulation* is not yet incorporated, one might foresee virtual players on the playground (simulating a certain attainable improvement of a player), or exemplify in the app how medication intake might change performance.

Many principles regarding *Dialogue Support* are also taken into account to some extend: *suggestions, similarity, liking*, and the *social role*. Other elements also provide interesting possible additions. *Praise*, although the winning team of the playground game is always shown and praised, the app could use some more praising elements when a user reaches a personal goal. *Rewards*, we tried to provide meaningful rewards by having impact (unlocking levels) in a game separate from the app, akin to an approach applied for digital games were achievements in one game resulted in rewards for another [19]. Power-ups at the start of a game, or more aesthetic rewards both in the app and the playground could also be considered. *Reminders*, the goals are visualized and can serve as a passive reminder (more in the form of *self-monitoring*), however the intended active type of reminders are not yet specified and could be of additional value.

Regarding *System Credibility Support* elements the systems clearly has a level of trustworthiness, expertise, authority, third-party endorsements, and surface credibility (mainly due to the help of the health care professionals involved in the project). The principle of *real-world feel* suggests it would be worthwhile to also include possibilities to contact the doctors about tips in the app. Although some third-party endorsements are inevitably linked with the cooperation of doctors in the project, more endorsements for instance of patient interests groups, and the hospitals (e.g. logos) could be helpful for the persuasive power and implementation of the system. The principle of *verifiability* suggests that further information and sources could be provided in the form of links, for instance regarding the hints or the level of the set personalized goals.

The systems also include many *Social Support* principles, mainly due to the ranking system and social play aspects: *social learning, social comparison, cooperation, competition,* and *recognition*. The latter could also be improved by creative appraisal of behavior similar to achievements in popular games: "Great you are this week's busy boots boy" or by using our contacts to show images, videos, and quotes of well-known sport heroes. Regarding *social facilitation* as well as *normative influence*, it is also interesting that we plan to place a playground at the hospital waiting room, where multiple children with asthma can play the game together, perhaps even together with parents and a passing-by doctor, which might help to increase the norm for amount of activity.

We can conclude that the PSD framework can efficiently be used for providing many valuable suggestions, even when an app is linked to a playground. Once we incorporate some of these suggestions, we still remain with the challenge to evaluate the level of success in a more summative way based on actual use. For instance, the scope of the project does not allow for doing a more thoroughly planned RCT, or doing the required long term study (e.g. 3+ months). At the same time we expect that the novelty, and tendency of children seen previous research to be positive during evaluations, will be of influence and that for this and other reasons the long term adherence could drop compared to results from simple user tests. A challenge of the multi-disciplinary work is that we need to design both creative solutions while addressing appropriate targets. All members of the team should work closely together in order to provide valuable, new, and refreshing persuasive technologies. Furthermore, as is suggested with the PSD model, to do so not only the medical professionals need to understand aspects of technological concepts, the HCI professionals also need to understand the user and context of use. Another challenge beyond the design and showing some scientific proof will be to actually incorporate into daily practice. Several possible advantages could help to facility this process such as an entertaining and social environment to stimulate activity while providing opportunities for automatic behavior analysis (cf [16]). Furthermore, we believe that the close cooperation with health care professionals from two different hospitals could be a persuasive element for other interested groups.

5 Conclusion

In this paper we present our work on the AIRPlay project. The goal of the project was to develop a proof-of-concept which combines a coaching application that is able to monitor physical activity of a young asthma patient, provide feedback based on this activity data, and integrates this application with an interactive playground. The integration of the coaching application with the interactive playground allows us to create a fun way in which children can interact with the system to improve the current management of asthma among children. The AIRPlay proof-of-concept can be improved by implementing knowledge from the field of persuasive technology and behavior change support systems in a more structured way. The PSD model can be used to improve or add features to the system to maximize the impact of the system on the management of asthma among children or to apply and translate the concept into applications for other (chronic) conditions. Interesting topics to explore are the way how knowledge from these fields can help to evaluate the system and to design a next version of the AIRPlay system.

References

1. Suijkerbuijk, A., de Wit, G., Wijga, A., Heijmans, M., Hoogendoorn, M., Rutten- van Mlken, M., Maurits, E., Hoogeveen, R., Feensta, T.: Maatschappelijke kosten van astma, copd en respiratoire allergie. Nederlands Tijdschrift voor Geneeskunde 157(A6562), (2016).
2. Boerdam, A., Knoops, K.: on behalf of Centraal Bureau voor de Statistiek, "Astma en copd in beeld," pp. 1–19, (2016).
3. Welsh, L., Roberts, R., Kemp, J.: Fitness and physical activity in children with asthma. Sports Medicine 34(13), 861-870 (2004).
4. Van Den Bemt, L., Kooijman, S., Linssen, V., Lucassen, P., Muris, J., Slabbers, G., Schermer, T.: How does asthma influence the daily life of children? Results of focus group interviews. Health and Quality of Life Outcomes 8(5), 1–10 (2010).
5. Cassim, R., Koplin, J.J., Dharmage, S.C., Senaratna, B.C.V., Lodge, C.J., Lowe, A.J., Russell, M.A.: The difference in amount of physical activity performed by children with and without asthma: A systematic review and meta-analysis. The Journal of asthma: official journal of the Association for the Care of Asthma 53(9), 882-892 (2016).
6. Leinaar, E., Alamian, A., Wang, L.: A systematic review of the relationship between asthma, overweight, and the effects of physical activity in youth. Annals of Epidemiology 26(7), 504–510.e6 (2016).
7. Walker, T.J., Reznik, M.: In-school asthma management and physical activity: Children's perspectives. Journal of Asthma 51(8), 808–813 (2014).
8. Mancuso, C.A., Choi, T.N., Westermann, H., Wenderoth, S., Wells, M.T., Charlson, M.E.: Improvement in asthma quality of life in patients enrolled in a prospective study to increase lifestyle physical activity. Journal of Asthma 50(1), 103–107 (2013).

9. Vahlkvist, S., Pedersen, S.: Fitness, daily activity and body composition in children with newly diagnosed, untreated asthma. Allergy 64(11), 1649–1655 (2009).
10. Apter, A.J., Reisine, S.T., Affleck, G., Barrows, E., ZuWallack, R.L.: Adherence with twice-daily dosing of inhaled steroids: socioeconomic and health-belief differences. American journal of respiratory and critical care medicine 157(6), 1810–1817 (1998).
11. Burgess, S.W., Sly, P.D., Devadason, S.G.: Providing feedback on adherence increases use of preventive medication by asthmatic children. Journal of Asthma 47(2), 198–201 (2010).
12. Wiecha, J.M., Adams, W.G., Rybin, D., Rizzodepaoli, M., Keller, J., Clay, J. M.: Evaluation of a web-based asthma self-management system: a randomised controlled pilot trial. BMC pulmonary medicine 15(1), 17 (2015).
13. AlMarshedi, A., Wills, G., Ranchhod, A.: Gamifying self-management of chronic illnesses: A mixed-methods study. JMIR Serious Games 4(2), e14 (2016).
14. Charlier, N., Zupancic, N., Fieuws, S., Denhaerynck, K., Zaman, B., Moons, P.: Serious games for improving knowledge and self-management in young people with chronic conditions: a systematic review and meta-analysis. Journal of the American Medical Informatics Association 23(1), 230–239 (2016).
15. van Delden, R., Moreno, A., Poppe, R., Reidsma, D., Heylen, D.: A thing of beauty: Steering behavior in an interactive playground. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '17), 2017, pp. –.
16. Moreno, A., van Delden, R., Poppe, R., Reidsma, D., Heylen, D.: Augmenting play spaces to enhance the game experience a tag game case study. Entertainment Computing 16, 67–79 (2016).
17. Oinas-Kukkonen, H., Harjumaa, M.: Persuasive systems design: Key issues, process model, and system features. Communications of the Association for Information Systems 24(28), 485–500 (2009).
18. van Delden, R., Moreno, A., Reidsma, D., Poppe, R., Heylen, D.: Steering gameplay behavior in the Interactive Tag Playground. In: Aarts E. et al. (eds) Proceedings of European Conference on Ambient Intelligence, Lecture Notes in Computer Science, vol 8850, pp. 145–157. Springer, Cham (2014).
19. Hamari, J., Veikko, E.: Framework for designing and evaluating game achievements. In: Proc. of DiGRA 2011. DiGRA/Utrecht School of the Arts, pp. 1–20 (2011).