How to Design Game-based Healthcare Applications for Children?
A Study on Children's Game Preferences

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Keywords: Gaming, Game-based, Game Preferences, Gamification, Game Design, Framework, Classification, Taxonomy, Player Type, Telemedicine, ehealth, Health Informatics, Tailoring, Adherence, Engagement, Children, Asthma.

Abstract: Game-based design can be used to develop engaging health applications for children. This engagement can only be realised when design is tailored to their preferences. In this study we investigate game preferences of children and translate these into design recommendations. Game preferences of children aged 6 to 12 were assessed through a questionnaire. Outcomes were classified by means of the 7D framework which divides game content into seven linear domains. Significant differences in mean scores among demographic subgroups were explored. Sixty-five children participated (M=9 years, SD=0.24, 36 boys, 29 girls, 8 children with asthma). Data showed high preference for content in domains novelty ($M_{novelty}$=63) and dedication ($M_{dedication}$=70). Analysis resulted in subdivision of scores based on gender, age and playing frequency. Striking differences in scores were found between boys and girls in discord (M_{boys}=62, M_{girls}=19), intensity (M_{boys}=60, M_{girls}=27), rivalry (M_{boys}=53, M_{girls}=31) and threat (M_{boys}=64, M_{girls}=25). To design games for children we recommend to stimulate curiosity by offering variation and discovery, to enable achievement, learning and social contact. A divergence in preferences for boys and girls must be regarded. Opposed to boys, girls may lose interest in games that have violent or scary content, that are mainly competitive or demand continuous effort.

1 INTRODUCTION

Health informatics can bridge the distance between healthcare professionals and enable patients to receive treatment in their daily living environment (Jansen-Kosterink, 2014), thereby alleviating the increasing demand for care and improving the autonomy and quality of life of patients. Despite that such telemedicine applications contribute to positive health outcomes (Huis in 't Veld et al., 2010), adherence seems restricted to several weeks of use(Tabak et al., 2014, Evering, 2013). Game-based design may be a strategy to increase adherence as introducing elements of game content to telemedicine applications is hypothesised to better engage the patient in using the application (Primack et al., 2012), thereby facilitating underlying treatment objectives (Baranowski, 2008). Moreover, applying game-based design may be able to sustain engagement for a prolonged time.

In order to successfully design game content that appeals to a specific target group, an understanding of their preferences regarding this game content is essential. To express these preferences, we can describe the user in various ways. Two commonly used approaches are player taxonomies and game genre (or form) classifications. A well-known player taxonomy is the Bartle player typology (Bartle, 1996), which classifies players into four types that represent the player's preferred behaviour within the game. Such player taxonomies like Bartle or e.g. (Yee, 2005) usually originate from analysis of a specific type of game and its players, and can therefore not be generalised or used outside of their context (Dixon, 2011). Also, the classes the models consist of are fixed and non-linear, thereby not

Vette, A., Tabak, M. and Vollenbroek-Hutten, M.
How to Design Game-based Healthcare Applications for Children? - A Study on Children's Game Preferences.
DOI: 10.5220/0006584804220430
In *Proceedings of the 11th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2018) - Volume 5: HEALTHINF*, pages 422-430
ISBN: 978-989-758-281-3

forming a complete description of all preferences a user may have. The other approach, expressing preferences through game genre or form (such as a simulation, shooter, educational, role-playing, etc.), gives an overall representation of a set of game features, which is not uniformly described among various game developers (Apperley, 2006). Neither of these approaches therefore allow for accurate assessment of preferences that is needed to synthesise into recommendations for the design of new game content, as the information on the player from a player typology is limited and too high level from a genre classification.

Instead, particularly as we envision to add game content to healthcare applications to prolong adherence, information on the player's preferences needs to be more detailed. This would correspond to a model that allows us to describe games by their actual characteristics, which would enable us to express preference of the user for specific game content on a much more profound level. We expect that by using such a model, we have more insight in how the individual should be addressed through game design but also how a group of users should be approached to realise more engagement.

As such, we developed a model for the classification of game content in earlier work (De Vette et al., 2017); the '7D framework'. This model can be used to assess and map the preferences of users for game content, resulting in a detailed description of these preferences that can be used to design new content. The model can be used to gain insight in whether or not demographic or psychosocial differences exist that may have implications on the design of the game content should be taken into account. The 7D framework can also be used to analyse and make explicit the content of existing games. The theoretical foundations for this model originate from the five factor model of personality (McCrae and Costa, 2008) and its translation into gaming semantics, the five domains of play theory (Vandenberghe, 2012). The 7D framework structures game content along seven linear domains that are defined by a set of characteristics per each domain extreme, as shown in *figure 1*. Discord and rivalry were originally represented by a single domain in previous versions of the model, as were social and intensity, hence they have been given the same colour in the figure.

Applying the 7D framework and its precursors to investigate the preferences of older adults group showed, in short, their preference for high novelty content and (cognitive) challenges, and an outspoken disfavour for intense, violent and frustrating content (De Vette et al., 2015, 2017). This research resulted in the development of a game-based self-management platform for older adults (De Vette et al., 2016) using a storyline, enabling exploration, containing puzzle-

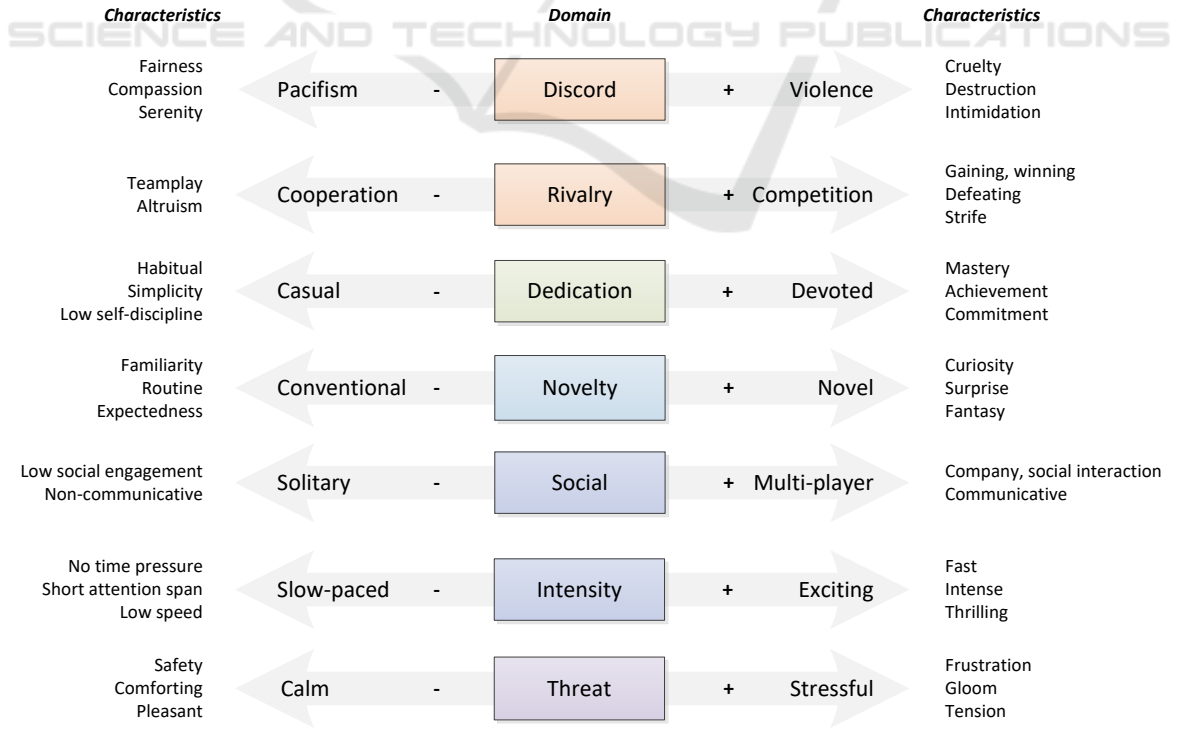

Figure 1: The 7D framework - a model for game content along seven linear domains.

oriented mini-games to sustain the motivation of the user. This game is currently under evaluation to study its effectiveness, but from preliminary results we find that the translation of the user preferences into game design has been successful. Now, we aim to explore the use of this model to gain insight in the preferences of other groups.

Unlike the older adult, children are a more common consumer of video games making the success of a game-based approach in healthcare applications more likely. Games are regularly applied for children outside the goal of entertainment, and numerous examples of serious games (Charlier et al., 2016) and game-based learning programs can be found (De Sousa Borges et al., 2014). However, additional research is needed to determine the game design that best promotes effectiveness of games in health informatics (Baranowski., 2015). Just like older adults (De Vette et al., 2015), children do not fit within the researched target groups using existing user classifications, nor do these models fit the context of digital healthcare applications. To the best of our knowledge, we are unaware of an existing framework that can be used to measure and elaborate game preferences of children on the level of core game content.

In this study we aim to gain insight in the preferences of children regarding game content and translate these preferences into design recommendations for engaging game content for children. To do so, we assess the preferences of children along the 7D framework and research whether significant differences in preferences exist among subgroups of children. This could give us a starting position in tailoring game-based telemedicine applications to this target group.

2 METHODS

2.1 Design and Participants

The study is cross-sectional. The participants were school-going children in the age of 6 to 12 years old. Local primary schools were invited for a Science Day taking place at University of Twente, the Netherlands. During this day, children were taught about the university and invited to participate in all kinds of activities related to technological innovation. Participants and their parents were informed on beforehand about the activities of the Science Day by the organisation of the event through an information letter. In addition, a second group of children with asthma within the same age range participated one day later. These participants were recruited via the children's department at Medisch Spectrum Twente, Enschede. For both groups, parents gave their informed consent prior to participation. Also, children's participation was voluntary and no exclusion criteria were applied.

One of the activities was playing on an interactive playground developed in the AIRPlay project (Klaassen et al., 2017), to support self-management of children with asthma and to promote their physical activity in a fun and unobtrusive manner. This playground uses floor projection and movement tracking to generate the playing field for a game inspired by the children's game 'tag'.

2.2 Measures and Materials

We assessed the preferences of children by using a questionnaire based on the 7D framework. The domains, as shown in *figure 1*, are 1) discord, which features peaceful versus violent content, 2) rivalry features cooperation versus competition, 3) dedication the appreciation of a game that requires low self-discipline ('casual') versus a game that is achievement-oriented ('devoted'), 4) novelty the preference for conventional, routinely or real-world versus fantasy, curiosity and variation, 5) social features the opposition of the amount of interaction with others, between solitary and multiplayer, 6) intensity holds slow and relaxed against fast, intense and time pressured, 7) threat the acceptable amount of negative feelings that the game can cause in the player, ranging from calm and lovely to frustration and fear.

Each domain is a linear scale (ranging from 0 to 100) described by two extremes. These extremes are described by characteristics, that can be translated into actual game features. We deduce our recommendations for game design from the measured scores on the different domains, and on our analysis of scores of identified subgroups.

The questionnaire was adapted to the target group by keeping the questions concise and illustrating them with simple images. Also, the number of questions was limited to a minimum of 11 questions by measuring two aspects of the more complex domains of rivalry, dedication, novelty and social, and one of the simpler domains intensity, threat and discord. All questions were rated on a 1 to 5 scale, each question was illustrated by two images of the extremes and an example in text *(fig. 2)*. The question was 'Which [example] do you like more in a game?' ("I like [example A] better than [example B]"). The average

scores were calculated for the seven domains and expressed in terms of percentages.

Demographics, including information on favourite games, playing behaviour and access to devices, were assessed in the questionnaire.

2.3 Procedures

Measurements of both groups took place at University of Twente and occurred in the same manner. Groups of up to eight children were invited to play on the interactive playground. The children took turns in forming two teams of two players. Playing continued for approximately five minutes. Subsequently, the group of 8 participants was asked to fill in the questionnaire.

2.4 Data Analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS v.22). Data distributions of the domains were analysed using the Shapiro-Wilk test, descriptives and boxplots. All domains were found non-normally distributed for all participants. Results are presented as mean and median domain scores. Subgroups were identified by comparing mean scores and analysing significance levels using the Mann-Whitney test for nonparametric distributions.

The principal findings are presented in a visual overview using the domain scores of all participant as well as the most striking subgroup(s) based on the highest number of significantly different domain score means. Univariate linear regression analysis was used to study the explained variance in the domains by both gender and playing frequency.

3 RESULTS

Sixty-five children participated (mean age 9, 36 boys and 29 girls). *Table 1* shows the game preferences of all participants. Subgroups were identified in comparing means in gender, age and playing frequency. This resulted in partitioning of gender in 1) boys and 2) girls, age in 1) 6 to 9 years old and 2) 10 to 12 years old, and playing frequency in 1) frequent players (daily to at least weekly) and 2) non-frequent players (not regular to never at all). A trending difference ($p < 0,10$) was found between the scores of children with and without asthma on the domain novelty (M asthma = 47, M non-asthma = 65).

Figure 3 visualises the scores of all participants and of boys and girls, as this subgroup shows the largest number of significant differences. This graph shows the uniformity in scores on dedication, novelty and social, and the scores on discord, rivalry, intensity and threat that appear to be determined by the clear division in scores of boys and girls. The domains dedication and novelty receive the highest scores from all participants, indicating an outspoken preference for content in these domains. The score on dedication suggests that these children have a preference for games that require effort and in which goals can be achieved. The score on novelty suggests a preference for variation, discovery, fantasy and creativity instead of more predictable content, such as football or racing. Significant differences were found

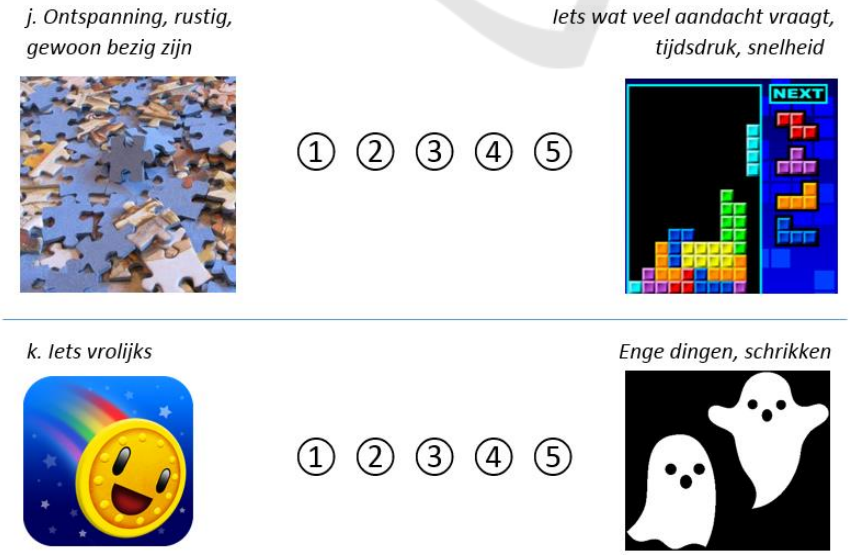

Figure 2: Fragment from the questionnaire (questions measuring intensity and threat).

between boys and girls on the domains discord, rivalry, social, intensity and threat. Social involvement through a game seems to be preferred by girls more than boys. On average, girls indicate a much different preference for discord, rivalry, intensity and threat. On the scale of discord, in which participants indicate their preferences between peaceful and violent content, boys give a high and girls a low score. A contrast of the same extent can be found in intensity, that separates a relaxed activity from one demanding focus and attention, and the presence of time pressure and speed, and threat, cheerful against disturbing content. Also in rivalry, in which preference between working together and competing as well as helping others to win against defeating others is measured, boys indicated a much higher preference for the latter.

A significant difference was found between the means of the two age groups on the domain social ($p = 0,033$). Upon analysis of the histograms of the two age groups (data not shown) we find that the younger group is more inclined to choose for the extremes (values 1, 3 or 5) while the older group is capable of indicating preferences on a more subtle level (also using values 2 and 4). All except one participant, who preferred playing alone, indicated to prefer playing together with classmates, friends in the neighbourhood or sports club and/or siblings or other family members.

Significant differences in scores for different playing frequencies were found in domains discord, rivalry, intensity and threat (missing data for 8 children who did not answer this question). Frequent players score on average about twice as high on these domains than the less frequent players. 81% of boys indicates to be a frequent player, of the girls this is 15%. However, there is a high significant correlation between gender and playing frequency. Gender shows to be a more important predictor for the domain scores discord rivalry and threat than playing frequency based on higher explained variance in linear regression analyses, while playing frequency was more important for the domain intensity (data not shown). Subanalysis of the scores of frequently playing boys (n = 25) and non-frequently playing boys (n = 11) shows that their preferences differ on the domain intensity (M frequent = 72, M non-frequent = 34).

Looking into favourite devices and games of both groups we see that children in the high playing frequency group indicates to favour using consoles such as PS4 to play games such as Call of Duty and GTA, and children in the low playing frequency group often do not indicate a specific favourite or mention a website offering various mini-games. From all participants, 14 children indicate a specific console or PC game as their favourite game, 15 children mention Minecraft (5 of them girls).

Table 1: Average scores on the seven domains (significant differences ($\alpha < 0,05$) in means highlighted).

		Discord	Rivalry	Dedication	Novelty	Social	Intensity	Threat
All (n = 65)	*mean*	43	43	70	63	58	45	47
	median	38	50	75	63	50	50	50
Boys (n = 36)	*mean*	62	53	74	60	51	60	64
	median	63	50	100	63	50	75	75
Girls (n = 29)	*mean*	19	31	65	66	66	27	25
	median	13	25	75	75	75	25	13
6-9 years (n = 28)	*mean*	47	47	67	64	50	42	49
	median	44	50	100	69	50	50	50
10-12 years (n = 31)	*mean*	38	39	73	61	66	49	44
	median	38	50	75	63	75	50	50
Frequent players (n = 29)	*mean*	58	53	76	66	53	67	66
	median	63	50	100	63	50	75	75
Non-frequent players (n = 28)	*mean*	25	34	64	64	64	26	30
	median	25	25	75	69	63	25	13
Asthma (n = 8)	*mean*	48	41	69	47	55	34	34
	median	63	25	63	50	50	0	25
Non-asthma (n = 57)	*mean*	42	43	70	65	58	47	48
	median	38	50	75	63	50	50	50

4 RECOMMENDATIONS

Based on the findings of this study we recommend the following when aiming to engage children through game design. These recommendations suit the approach of designing one game to address the full target group.

***Novelty:* Focus on Stimulating the Children's Curiosity and Avoid Routine.**
New game content should be introduced regularly. Variation can be created through for example new rules, mechanisms or visual elements. Enabling children to use their imagination, be creative and add their own variations to the content, or enable emergent gameplay, may be a valuable feature. A novelty theme (fantastical, fictional) may also be more suitable than a real-world theme.

***Dedication:* Provide Content that Enables Achievement.**
Games should always be sufficiently challenging. For children, it may demand an effort to learn skills necessary to play the game. A trial-and-error approach to do so can be rewarding. Include clear feedback on achievements. Making content unlockable may serve both the preferences on novelty and dedication.

***Social:* A Game Should Enable Playing Together.**
The preference for social contact is slightly dependent on the age and gender ratio of the group, but in general children prefer playing together rather than on their own.

***Discord and Threat:* A Neutral Approach Would Be Advised on Violence and Scary Content.**
We observed a preference for violent video games particularly in boys. Most girls may be put off quickly by for example fighting games, as most boys will probably not be interested in overly cute games. Violent and scary game content should always be age appropriate.

***Rivalry:* Competition and Cooperation May Be Used Alternately to Keep a Game Interesting for Both Boys and Girls.**
In a multiplayer game, team play or 'helper' functions may be added next to mechanics enabling competition, such as setting challenges for other players.

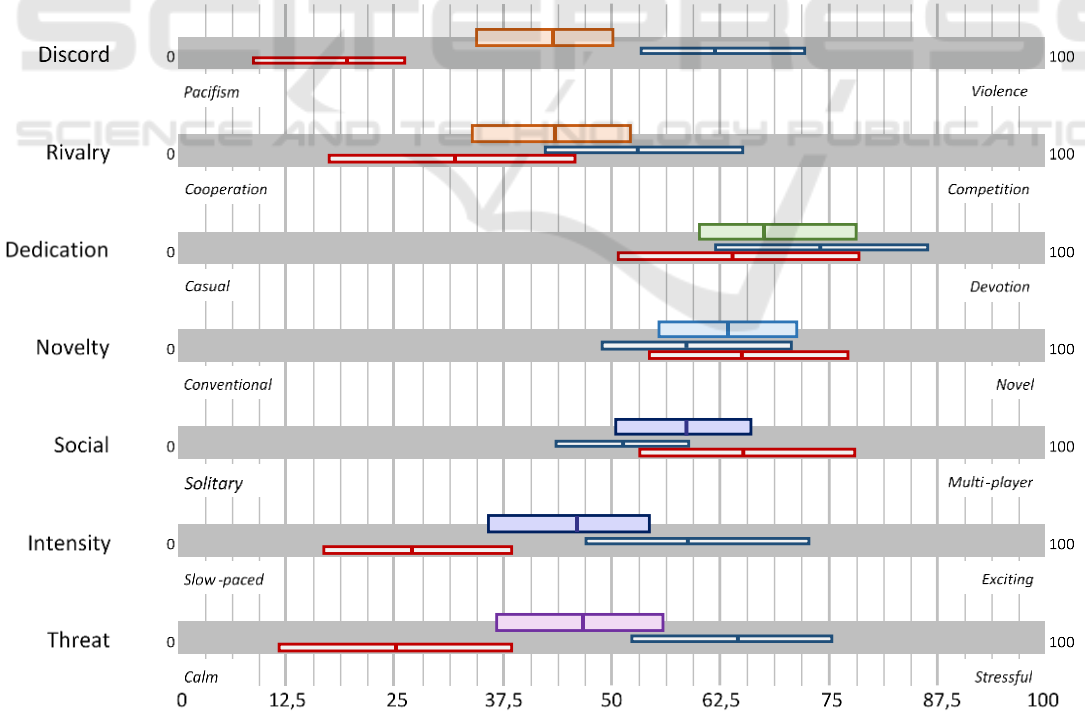

Figure 3: Overview of preferences mapped on the 7D framework (average and 95% interval domain scores) of all participants (top), boys (middle, blue) and girls (lower, red). The upper box in each domain shows the average score of all users and the 95% interval. The smaller boxes show the scores of boys (middle) and girls (lower) in the same manner.

***Intensity:* A Moderate Intensity Should Address Both Boys and Girls.**
We do however recommend keeping in mind the preference for lower intensity of most girls. Games should provide the opportunity to choose an intense as well as a more laid-back playing style to avoid girls losing interest from a game that demands continuous effort, movement or focus. We believe that this is the case particularly when developing games that involve physical exercise.

5 DISCUSSION

The aim of this study was to gain insight in the game preferences of children, in order to synthesise recommendations for game design to support the development of engaging game-based telemedicine applications. Using the 7D framework, the preferences of 65 children were assessed resulting in a graphical overview of preferences. The scores suggest an overall approach towards game design for this target group when attempting to engage all members of the target group through one game, which has been the basis for a set of game design recommendations.

It is important to identify and take into account different preferences from subgroups within a population to avoid that game content is developed that may either be too much of a compromise or is disliked by the majority of one of both groups. While gender was a more important predictor to game preference in this study, we do not assume that we should ignore playing frequency. We know that girls are interested in games but that they prefer much different characteristics (Kafai, 1998). The current offer of videogames may determine that mostly boys are the frequent players. There is a group of boys that play frequently who indicated a much higher preference for violent, intense and disturbing content than the boys that play less often. Also, some have access to consoles with games that may be considered inappropriate for their age because of their violent content. We expect that this subgroup may be hard to please, if at all, as they are used to high-end games, which moreover serve a set of preferences that may put off many others.

Children with chronic conditions may form another subgroup. Carefully interpreting the scores, we expect that these children are more reserved (lower novelty) and choose for a game that is less intense (lower intensity). Recommendations for game design for this group may include for example giving them the chance to discretely take breaks or exhaust themselves less than the others. More data is needed to better understand the impact a chronic condition, such as asthma, may have on game design.

Several aspects of this study lead to limitations when generalising our findings for a greater public. Firstly, our sample included children from local primary schools. Cultural and educational differences that may be of great influence on the results were not taken into account. Divergent reading and writing abilities among participants, not necessarily related to age, may have led to misinterpretation of the questions. Also, the Science Day and the playing on the AIRPlay interactive playground may have influenced the results. Secondly, validation of the 7D framework is currently in progress. As such, the creation of the questionnaire as well as the interpretation scores into recommendations is to some extent subjective. It is vital that the intention of the designer is in accordance with the perception of the target user on game content, future work should include measures to align both frames of reference. For example, a game designer may develop gameplay that seems very intense for a child, while the child itself interprets this differently. Furthermore, it should be noted that the interpretation of the recommendations given is open to the game designer, as creating a satisfying game is not merely a sum of parts but a design process in itself. As an example, a high score on dedication indicates that it is more likely that the user prefers game content that demands devotion to play. This is described by the example characteristics mastery, achievement and commitment. In case of a high score on dedication, we would recommend to include the need for skill development in order to advance in the game (unlike a more habitual game that would always require the same amount of skill). A game designer may then choose how to realise this aspect. Lastly, this study included a limited number of participants with asthma. We expect that minor differences will show between the asthma and non-asthma group in a larger dataset. At the time of writing the dataset is being expanded with the data of more children with asthma.

In current and future work, we aim to fill in a research gap on the existence of a method to elaborate the preferences of any target group into a specific characterisation to provide a starting position for game-based design in health informatics. To ensure validity of the 7D framework, we would propose to extend research with 1) a comparison of the results with existing literature on children's playing behaviour, preferences and personality, 2) creating a more elaborate questionnaire that includes a larger number of game content characteristics, as we assume

this can lead to more detailed recommendations for game design, and to 3) apply the design recommendations in practice to evaluate to measure their effectiveness in engaging the target group to the healthcare application. Furthermore, we aim to investigate if certain domains are more important than others to the overall engagement when developing a strategy for game design. In future work we aim to respond to any differences that may be found in preferences for children with or without chronic conditions, in order to predict which strategies may be successful for these children based on game preferences, besides attitude or different physical capabilities.

ACKNOWLEDGEMENTS

We would like to thank all participants and their parents. This work was part of the AIRPlay project (www.airplay.nl), financially supported by the Pioneers in Healthcare Innovation Fund (PIHC round 2015). This fund (provided by University of Twente and the hospitals Medisch Spectrum Twente and Ziekenhuisgroep Twente) aims to facilitate the introduction of innovative technology into the clinic.

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