Persuasive technology design for children: Changing behaviours, improving knowledge, and encouraging positive attitudes towards drinking water

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Abstract

Drinking water is essential for health and life. However, the majority of children do not meet the European Food Safety Authority water intake recommendation. In this paper, we investigate the effectiveness of an intervention designed to support behaviour change, improve knowledge, and foster positive attitudes of children towards drinking water. The design of the intervention and the interactions were personalized to suit the context and to meet the unique needs, interests, and preferences of the targeted age group. Inter-active storytelling techniques and persuasive strategies were used to motivate children to increase their water intake. We conducted a comparative study to evaluate the design of the intervention. The results showed that the average number of glasses of water children drink per day increased significantly after participating in the intervention. Knowledge improvement and a positive change in attitude were observed directly after participating in the intervention and eight days later. These findings have implications for future work on personalization and designing persuasive interventions for children.

Keywords

Persuasive technology, persuasive games, serious games, behaviour change, health, personalisation.

1. Introduction

Drinking water is essential for health and life. While a human can survive for more than fifty days without eating, a few days without adequate hydration will be fatal [3]. Water is the largest component of the body, constituting approximately 60% of an adult's body weight and 75% of a child's body weight [3]. Hydration is critical for temperature regulation and maintenance of body functions and processes [44]. If the human body does not receive adequate fluid intake, also known as dehydration, health issues such as kidney stones, cancer and problems with the heart valves could occur [4]. Dehydration may also lead to tiredness, headaches, irritability, fainting, loss of appetite, dizziness, and collapse [4]. Therefore, the European Food Safety Authority (EFSA) has set adequate water intake recommendations, which concern the total water intake per day for different age groups and genders [20].

Despite the tremendous importance of adequate hydration, too little water is drunk. Research among 10,000 Dutch people has shown that only 15% of the participants meet the adequate water intake, even though half of the participants thought they drank enough water [48]. Among children, this percentage is even higher. In the USA, Lebanon, France, and the UK, studies investigated water drinking behaviours of children aged 4 to 13 years old [18,26,55,56]. Overall, 81.2% of these children did not meet the EFSA water intake recommendations.

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This growing global concern motivates research into persuasive interventions that support children to adopt healthy water drinking habits. Several studies have been conducted among children to change their behaviours and attitudes, and, in particular, health promotion is a frequently returning subject [43]. However, further investigation is required to optimize personalisation to a specific context and tailor inter-actions suited to younger age groups. In this paper, we investigate the effectiveness of a persuasive intervention that aims to support behaviour change, improve knowledge, and encourage positive attitudes of children towards drinking water. The findings have implications for future work on personalization, behaviour change interventions, and persuasive games that promote the formation of healthy habits in children.

2. Related work

Persuasive technologies and behaviour change interventions are designed to motivate, shape, and reinforce beneficial behaviours and attitudes [21,41]. Research efforts have been directed towards investigating persuasive interventions across different domains, such as encouraging regular physical activity [39,30], motivating healthy eating [23,42,53,52], encouraging safe driving habits [9], or promoting sustainable travel behaviours [22,2]. With health being the second most significant domain for persuasive strategies [32], various interventions have been developed and evaluated to support the improvement of physical and mental health [43,49,13]. There is growing evidence in the literature showing that personalisation may contribute to increased overall effectiveness and adherence of persuasive interventions [29,38,8,28]. However, there is a need for further research into personalising technology to different age groups or developmental stages and tailoring interactions to suit a specific context.

Personalising the design of interventions to support behaviour change in children poses additional challenges. Cognitive and emotional development must be taken into account and appropriate strategies must be applied to reinforce desired behaviours. For example, using bright colours, sounds, positive reinforcement, and immediate feedback may lead to greater engagement from younger children, while an approach focused on decision-making and reasoning may be more appropriate for adolescents. Persuasive games could provide a novel solution to encourage the adoption of healthy behaviours, as the interactivity can increase the emotional quality of an intervention [40] and contribute to increased engagement and adherence [34]. In addition, persuasive games have a strong motivational pull [46], and simple game mechanics may be used to engage children and to communicate with them [17]. A growing number of persuasive games have been developed in recent years, designed to motivate healthy behaviours, such as encouraging physical activity and adequate nutrition [30,53,6,31]. Evidence in the literature shows that a motivated and interactive learning setting helps children to learn [16]. Therefore, the balance between challenge and action is important [16]. For example, the studies described in [1] and [24] are focused on changing behaviour and attitude towards healthy eating, by using persuasive strategies within a digital game in which healthy and unhealthy food is falling and players have to catch the healthy food and avoid the unhealthy food. In addition, the children are taught the benefits of healthy food and the negative effects of unhealthy food. Learning to distinguish healthy and unhealthy food choices through an enjoyable approach, without participants realising they are being positively influenced by the interventions, is one of the key contributors to design effectiveness in both studies. In addition, the design of the persuasive game presented in [24] is based on the Fogg behaviour model [21] and Bandura's Social Learning Theory [5]. It emphasises three factors that should be considered when using persuasive strategies and behaviour change techniques in games for children. Firstly, to engage the children, it should be related to their life (e.g., by using attractive elements of multimedia that are familiar to them). Secondly, the game should provide the possibility for the children to explore the game themselves. Lastly, it should be simple and fun to play. This is in accordance with related work investigating serious games for children. For example, an analysis of studies concluded that serious games and games for health can positively influence developmental and cognitive outcomes among children [7]. Moreover, studies have shown that playing games brings positive emotions and emotional stability to the players [45,25], and young children and adolescents choose to play games deliberately [15]. However, for serious games to be effective, the games should be fun and the learning assessment or behaviour change should not distract the player from the enjoyment.

Other studies have used the Fogg behaviour model [21] and Bandura's Social Learning Theory [5] in their design as well. For example, persuasive techniques were used to create a mobile game for children which aimed to inform them and transform their mindsets, by providing a new approach for campaigning against smoking [36]. In the game, children have to shoot cigarettes, which is alternated with screens providing information about the effects of smoking. The principles of praise, information quality, attractiveness, mobile simplicity, convenience and cause and effect have been applied in the game. Similarly, to the previously mentioned studies, they measured the children's current knowledge and attitude towards smoking, then asked the children to play the game, after which they repeated the measurements. Their results were positive, indicating that the game gained positive feedback and that it is effective at altering the mindset and attitude regarding personal and social situations.

Other persuasive strategies have also been investigated. For example, in the work described in [47] and [12], persuasive design principles were successfully applied to reduce dental anxiety and improve tooth brushing among children.

In the sustainability domain, the principles of feedback, praise, and comparison, combined with suggestive messages have been used to raise awareness of domestic energy consumption, by creating a simulated environment [6]. In the health domain, the principles of reward and feedback were applied to design a playful persuasive intervention that stimulates healthy eating for children, using color matching [27]. Their results were positive, concluding that children's eating habits can be improved using persuasive education. This study succeeds the work described in [37], which showed children love to play, and play based persuasion provides the most effective means of solving child behavioral problems. In a different study, a playful mug was created to help people develop healthy water drinking habits [33]. The work was founded on the principle of playfulness, trying to support habit formation by embedding behavior modification into a regular drinking mug, called Mug-Tree. Users have to take care of a virtual tree, by drinking enough water every day. Each mug of water is measured, and the effect is visualized on a screen. The design is based on enjoyment, active engagement and reinforcement and aims to motivate the users to drink water. However, despite the growing interest in persuasive interventions, there remains a need for further research into personalizing intervention design and interactions to suit a specific context and to meet the requirements and preferences of young children.

3. Research design and methods

We conducted a comparative study to investigate the effectiveness of persuasive intervention in changing the behaviour, attitude, and knowledge of children towards drinking water. The design of the intervention uses interactive storytelling techniques to stimulate behaviour change. The effectiveness of the intervention was measured using questionnaires before, immediately after, and eight days after participating in the intervention. The study was guided by the following research questions:

1. How effective is the intervention in motivating children to increase their water in-take?
2. How effective is the intervention in changing the attitude of children towards drinking water?
3. How effective is the intervention at improving the knowledge of children about the health effects associated with drinking water?

3.1. Outline of the experiment

To determine the behaviour, attitude, and knowledge of children towards drinking water, a questionnaire has been created (Q1). Next, using findings of the literature review, a persuasive intervention has been designed to change the behaviour, attitude, and knowledge of the children towards drinking water. The design of the game and the interactions were personalised to suit this context and be appropriate to the targeted age group. To detect a potential change, and measure the effectiveness of the intervention, the initial questionnaire was repeated directly after participating in the intervention (Q2). To detect a potential change in the longer term, participants were asked to complete the questionnaire again after eight days (Q3). Figure 1 gives an overview of the experimental setup.

Figure 1. Outline of the experimental setup.

3.2. Participants

We recruited children aged 8 to 9 years old from primary school education. For children aged 12 or younger to participate in scientific research, their parents have to give informed consent. Therefore, we created a consent form including information about the content, procedure, and goal of the experiment. This consent form has been distributed among the parents of two classes of primary school children in the Netherlands. Because the native language of these children is Dutch and they are not able to speak English, the language of the questionnaire and intervention is Dutch. A total of 25 participants were recruited (n = 25, 11 male (44.0%); 14 female (56.0%)), with a mean age of 8.50 years (minimum = 8; maximum = 9; SD = 0.50).

3.3. Development of a questionnaire to measure changes in behaviour, attitude, and knowledge

Before completing the questionnaire, participants were informed that participation is entirely voluntary, and an explanation was provided to reflect what is understood by drinking water. Thereafter, participants were asked to fill in their demographical characteristics, including their assigned alphanumeric code. This code is used to pair the answers of the participants of all three questionnaires, whilst storing the data anonymously. Next, they answered questions about their behaviour, attitude, and knowledge towards drinking water. To address the children, the explanation and questions have been formulated using informal and simple language.

The behaviour of the participants was measured using a question about the number of glasses they drink on average per day. To ensure consistency in the amount of water one glass consists of, the content of one glass has been set to 150 milliliters. This has been visualized using a picture of a glass. In addition, we included a comparison of the content of a glass of water with a famous drinking bottle, as can be seen in Figure 2.

Knowledge was measured by asking two types of questions: the required number of glasses participants should drink each day and an open question in which participants indicate the effects of drinking insufficient amounts of water.

Attitude can be described as consisting of three components: affective, cognitive, and behavioural. Therefore, attitude indicates the feelings, beliefs, and behaviours regarding the subject [35,50]. Hence, these three components should be taken into account when creating statements in a questionnaire. Furthermore, related work provides suggestions towards the construction of statements for attitude scales. Choice of words in accordance with the target audience is important, as well as keeping statements short and avoiding ambiguity and statements that can be interpreted as being factual [19]. The development of a questionnaire regarding children's attitudes toward health care has been previously researched in [11]. They created three scales, consisting of five answer possibilities. The like-dislike scale used five faces ranging from a smile to a frown to answer the statement. These recommendations were taken into account for the development of our questionnaire. To measure attitude, questions addressing all three of its components were included [35,50]. Furthermore, the guidelines of [19] have been used to create statements and questions. We included a similar scale in the questionnaire. However, the questions in Dutch have not been validated. The scale consists of five answer possibilities connected to a numerical scale, ranging from one to five (as seen in Figure 3). For each statement, the children indicate their answer by moving the bar to choose the applicable smiley.

Figure 2. Example of a water bottle (450 ml) and a glass of water (150 ml).

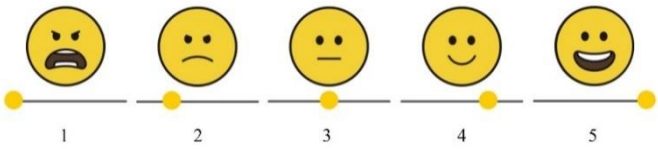

Figure 3. Numeric values matching with the five answer possibilities of the smiley scale.

3.4. Personalising the design of the persuasive intervention to children in the context of increasing water intake

The design of the persuasive intervention involved developing the storyline, inte-grating the game component, and setting up the materials and tailored interactions. Based on the related work, a framework of persuasive strategies has been created. Definitions of the principles have been derived from [21] and [36]. The framework is shown in Table 1.

Storyline. The storyline is the most important part of the intervention since it enables the trans-fer of knowledge and application of the persuasive strategies. Trying to appeal to children, we created a fictional story of a veterinarian helping a lion who is sick because of dehydration. The storyline used animal characters and focused on emphasising the negative consequences of reduced water intake. Figure 4 shows examples of story progression within the intervention. We focused on implementing the per-suasive principles of the framework created in Table 1. This resulted in four of the five strategies being implemented in the story and the last principle throughout the whole intervention. Table 2 shows an overview of the persuasive principles and their implementation and Figure 4 shows four scenarios of the story. The story comprised of the following sequence of events:

1. The children are told that they will help the veterinarian Anna to cure a sick lion.
2. Anna examines the lion, which is feeling sick: he has a headache and has fainted.
3. Anna concludes that the cause of his illness is drinking too little water.
4. Anna thinks back to the previous day when the doctor emphasized the importance of drinking water.
5. The doctor emphasizes the importance of drinking water and explains the effects of drinking too little, stating that children should drink 13 glasses of water each day.
6. Anna and the children collect water.
7. Anna and the lion drink water, after which the lion feels much better.
8. Anna reminds the children to drink 13 glasses each day, after which she thanks the children and leaves the lion to help other sick animals.
9. The story is finished, and the children are thanked for their help.

In addition to the persuasive principles, findings in the literature provide guidelines for creating a persuasive intervention. These guidelines have been taken into account for the design of the intervention. Therefore, a good balance between challenge, action and implementation has been realised by alternating reading parts with an active game element. Furthermore, while creating the storyline, we ensured the per-suasion and learning assessment do not distract the children. The explanation of the

cause and effects of drinking too little, given by the doctor can be considered very important regarding the goal of the intervention. Therefore, we decided to add an-other way to stimulate the memory and attention of the children, by adding icons of the effects of drinking too little water as can be seen in Figure 5.

Table 1.
Framework of persuasive principles as derived from [21] and [36]

Principle	**Explanation**
Praise	Technology may increase openness to persuasion through praise.
Authority	Having roles of authority included in computing technology increases the ability to persuade.
Attractiveness	Computing technology with an attractive appearance is presumed to be more persuasive.
Cause and effect	Showing target users, the direct connection between cause and effect can lead to behaviour and attitude change.
Mobile simplicity	Mobile applications that are simple and easy to use will be more likely to persuade.

Table 2.
Implementation of the persuasive principles

Principle	**Implementation**
Praise	After completing the game, the children are praised for their achievement. Furthermore, the veterinarian praises the children, and the lion thanks them while his appearance changes to happy.
Authority	The information and effects of drinking too little water are given by a doctor. The doctor represents a figure of authority through his knowledge and expertise.
Attractiveness	The storyline and game have been designed using fun icons and colourful styling. In addition, the setup of the intervention and the use of the Makey Makey engages the children.
Cause and effect	The doctor tells the children the effects of not drinking enough water, using icons as a visualisation. In addition, reward mechanics are used to motivate players to choose the correct drinks.
Mobile simplicity	The intervention is easy to use and the interaction of the children with the intervention is clearly explained.

Figure 4. Intervention scenarios 1, 3, 5, and 7 of the story.

Game. To actively involve the children in the story and add an attractive and enjoyable element, we integrated a game component, designed to support the narrative. The children play the game to help veterinarian Anna collect water for the sick lion and themselves. In the game, water, cola, and lemonade icons fall down the screen. The children have to collect points by catching the healthy drinks with the bowl. As can be seen in Figure 6, the icons have different values. Catching the glass and bottle of water provides positive points, but the children have to avoid the cola and lemonade since catching these will reduce their points. The score is updated after catching any icon. Simultaneously, when a drink is caught, the corresponding sound will be played: for catching water, the children hear a 'plop' sound, but when catching cola or lemonade, the children hear a negative 'beep' sound. Hereby, auditory feedback is added, indicating what (not) to catch. The goal of the game is to collect 26 points, which represents the number of glasses of water required for the story: 13 for the lion and 13 for the veterinarian. After collecting 26 points, the game stops and the story continues, with the veterinarian and lion drinking water, which makes them both feel much better. We chose this design to allow children to distinguish between healthy and unhealthy drinks. Although other drinks such as lemonade and cola also contain water, drinking plain water is recommended. This is due to the high amount of additional ingredients in other drinks, making these drinks unhealthy choices. We wanted to ensure that the intervention reinforces healthy water intake and does not persuade children to increase their intake of sugary drinks as a secondary effect of participation.

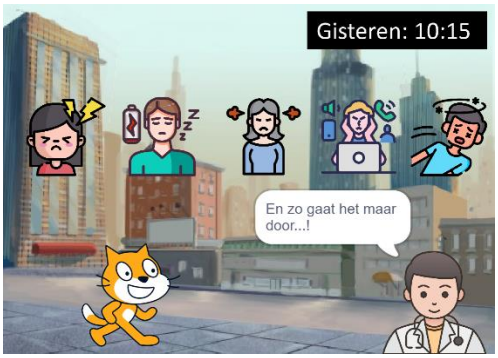

Figure 5. Example showing the use of icons while the doctor is providing an explanation.

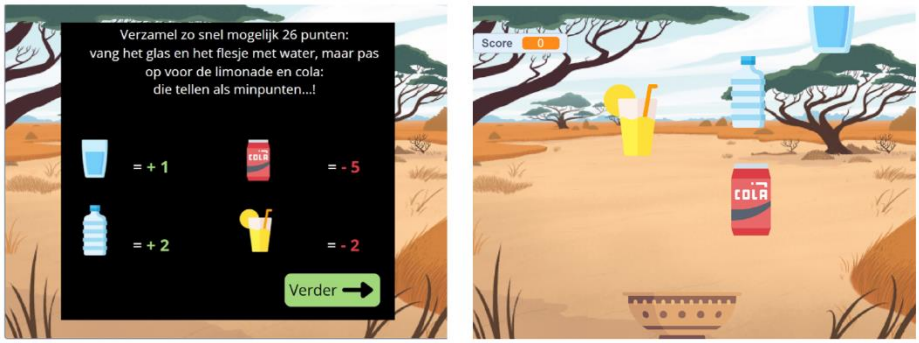

Figure 6. Example of the game instructions and mechanics.

Personalising materials and interactions. The intervention was created using the visual programming language Scratch. For the story, we let the characters come to life by adding timed messages. Therefore, participants had a set amount of time to read the text, after which it disappeared, and the next screen was shown. The meta-analysis in [10] discusses studies about aver-age reading speed. One study suggested that children of early primary school age read about 80 to 138 words per minute [51]. However, their study was performed in English. Therefore, following the pilot test, we decided to use the reading speed of 60 words per minute, accommodating any potential slower readers.

The game can be played using the right and left arrows on the keyboard of a computer to control the bowl that caught the drinks (Figure 6). However, to personalise to this specific context, we decided to turn two water glasses of 150 millilitres into controllers (Figure 7), to involve the children more actively, make the intervention more attractive, and give them an indication of the amount of water they should drink. For that, we created a setup using Makey Makeys.

The Makey Makeys allow us to connect objects to controls of a computer, using conduction. The two empty water glasses have been covered in aluminum foil and a wooden plank has been milled with two holes. These holes have been covered in aluminum foil as well and are connected to the Makey Makey using alligator clips (i.e., connected to the orange and yellow wire as shown in Figure 7). When putting down a glass in the right hole, the foil of the glass and the foil of the hole connect. This results in the bowl in the game moving to the right. Simultaneously, when putting down a glass in the left hole, the bowl moves to the left. Using this setup, the glasses of water have been turned into controllers. For the Makey Makey to work, the person controlling should be grounded. Therefore, each child wrapped their fin-ger with aluminum foil and connected it with an alligator clip to the EARTH part of the Makey Makey (i.e., connected to the green wire as shown in Figure 7). Three identical pieces have been created using this setup, to enable three participants to perform the experiment simultaneously.

Before the game is played, the setup is explained. Next, the children wrap aluminum foil around their finger and connect it to the Makey Makey after which they play the game using the glass controllers. After collecting 26 points, they disconnect the alligator clip and the foil and continue with the story.

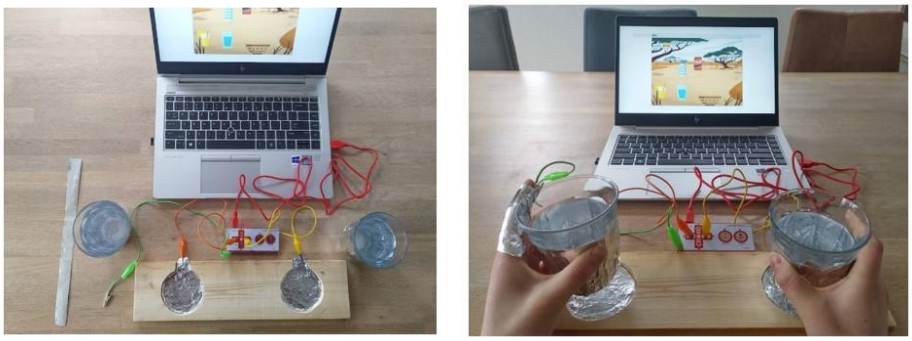

Figure 7. Example showing how a participant interacts with the intervention.

4. Results and discussions

The overall result analysis has shown a neutral comment from the participants. Students may have felt a sense of connectedness with the supervisors (more competency and relatedness level) than the working colleagues. This may be due to the knowledge and expertise of the supervisors in the same field students are researching. While on the other hand, working colleagues do not have similar tasks (as students work on their own research topics separate from others).

In the context of relationship building with supervisors, participants' answer was neither true nor false when they thought of connecting with supervisors using online tools. Supervisors' constructive feedback is vital to reliable doctoral dissertations [30]. One of the key issues to highlight is the need for more clarity and transparency between student supervisors. For example, the student may expect to get more solid and concrete feedback and research direction to follow. This leads to a communication gap between them, such as physical and online meetups needing to be more than students' expectations. In a study by [31], the author examined student engagement and challenges related to supervisory feedback. The research found notable differences between the perceptions of supervisors and students, particularly in areas such as student engagement, research experiences, and the various factors that contribute to challenges in supervisory feedback. Maybe some sort of fear was working within them; they were puzzled about what would happen in the meeting when sharing their work progress and getting feedback from them.

In the context of relationship building with working colleagues, students did not feel that their competency and relatedness level increased due to receiving peer-reviewing feedback from working colleagues using online tools. Maybe there have been some workplace envy and jealousy among them [32]. Thus, students may re-quire leadership training during their course degree as effective leadership can ad-just the existence of various types of envy and transform it into the actual productivity of the workplace [33].

Students' anxiety is relevant to their academic performance [34], such as reducing daily autonomy levels toward study progression. In our study, most participants' autonomy level was higher. The factors in increasing their autonomy level may be a positive vibe to meet with working colleagues, talks about progress reports or re-search plan writing, and related work reviews. One possible thing is that students might have a daily goal to meet the long-term milestone and divide their tasks into small daily portions to work daily towards a more significant milestone to increment their autonomy level.

Students' competence level could have been higher, indicating they might need to be more self-confident in doing their research study. Most participants' relatedness level was higher, meaning that most students have not experienced group work facilitated learning [35].

Getting feedback while doing peer-reviewing tasks using the online tool might bring positive effects, such as building a strong interpersonal relationship while using the real online tool. As in our study, participants only filled out the questionnaire but did not use the tool but pretended to have applied them. This directed us to further our research to go for a longitudinal study with an online tool.

4.1. Effects of the persuasive intervention on children's behaviour

A dependent samples t-test was used to measure the effectiveness of the persuasive intervention to encourage children to increase their daily water intake. There was a significant difference ($t(24) = -4.19$, $p < 0.001$) in the number of glasses of water children report drinking per day before participating in the intervention ($M = 3.24$, $SD = 2.07$) and eight days after the intervention ($M = 5.96$, $SD = 4.09$). Since before the intervention the children indicated that they drank 3.2 glasses per day with a maximum of 7 glasses of water, none of the children met the EFSA water intake recommendations of approximately 13 glasses of water per day [20]. This drinking behaviour is in line with the findings of [18,26,55,56] who showed that, on average, 81.2% of the primary school children do not meet the EFSA water intake recommendations. Eight days after participating in the gamified persuasive intervention, the indicated number of glasses of water almost doubled to an average of 6 glasses of water per day. Only two of the participants indicated drinking at least 13 glasses of water per day, meaning that 92% of the children still do not meet the EFSA water intake recommendations. Nevertheless, comparing the behaviour before and after the intervention, the children indicated that they drink significantly more

water, meaning that the intervention positively changes the behaviour of the children. The ob-served behaviour change, and the effectiveness of the persuasive intervention are in line with related work investigating the effect of persuasive principles (e.g. [27,36]).

4.2. Effects of the persuasive intervention on children's attitude

To detect a potential attitudinal change towards drinking water, the attitude variable had to be created. Therefore, for all three questionnaires, we averaged the answers to the eight attitude questions to create one attitude variable and we performed depend-ent t-tests to compare the means. There was a significant difference ($t(24) = -2.44$, $p < 0.05$) in attitude scores before the intervention ($M = 3.81$, $SD = 0.73$) and directly after the intervention ($M = 3.97$, $SD = 0.75$). The significant increase in attitude score suggests that the children rated the questions regarding the importance of drinking water higher. This supports the use of persuasive principles and suggests the intervention is effective for both behaviour and attitude change. However, the change in attitude is moderate, as the mean attitude score before the intervention was already high. No significant difference was found ($t(24) = -0.62$, $p > 0.05$) in attitude scores before the intervention ($M = 3.81$, $SD = 0.73$) and eight days after the intervention ($M = 3.89$, $SD = 0.81$). However, the attitude score does indicate a positive trend comparing the score before and eight days after, with the mean increasing by 0.08 points. This means that the intervention is effective in the short term, but this effect does not seem to last. This could possibly be due to the lack of repetition, as the children only participated in the intervention once. A study with a longer du-ration would allow the participants to engage with the intervention multiple times. After a habit is formed, a stronger effect on attitude may occur.

4.3. Effects of the persuasive intervention on children's knowledge

The knowledge of the participants was measured in two ways and the data was analyzed both quantitatively and qualitatively. First, by asking them to write down the required number of glasses of water they think they should drink per day. Their answers have been categorized, indicating whether they gave the correct answer (13 glasses each day) or not. The answer of one participant was removed due to a typo. We performed a McNemar's test to determine if there are differences in the dichotomous dependent variable between the questionnaires. In addition, participants were asked to write down the effects drinking too little water has on their bodies. These results have been categorized, indicating whether participants correctly recalled one or multiple effects discussed in the intervention. The discussed effects are fainting, tiredness, headache, irritability, problems concentrating and problems with your bladder, kidneys, and heart. The results of all three questionnaires were compared.

Figure 8 shows the distribution of the knowledge of the participants before, directly after, and eight days after the intervention. It indicates the number of glasses of water the children think they should drink per day. We divided these answers into two categories: Correct and Incorrect. Figure 9 shows the distribution of these categories for the three questionnaires.

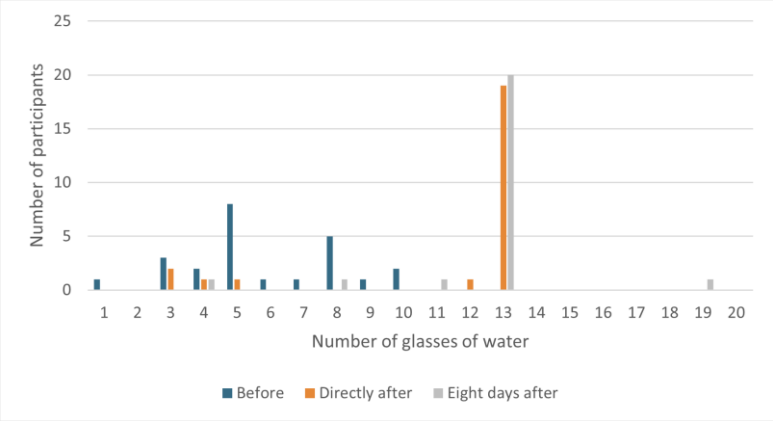

Figure 8. Number of glasses of water participants believe they should drink per day.

An exact McNemar's test showed a difference in knowledge before and directly after the intervention ($p < 0.001$) and a difference in knowledge before and eight days after the intervention ($p < 0.001$). Before the intervention, none of the children were aware of the number of glasses of water they have to drink per day. After the intervention 79.2% correctly recalled the 13 glasses. Eight days after the intervention, this percentage is even higher, with 83.3% of the children correctly indicating 13 glasses of water. Possibly, in the eight days between the questionnaires, children mutually discussed the intervention and the number of glasses they have to drink per day resulting in a higher number of children being able to correctly identify the recommended number of glasses of water per day. Overall, the intervention was effective at improving the knowledge of children regarding the recommended water intake.

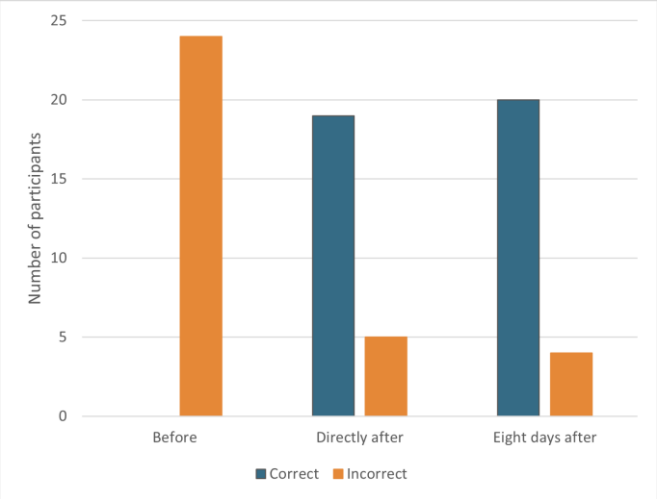

Figure 9. Correct and incorrect answers regarding the recommended water intake.

In addition, the qualitative analysis showed that before the intervention, children were not aware of the various effects of drinking too little water. Figure 10 shows that before the intervention, only 4 participants named one of the effects of drinking too little water that they would later encounter in the intervention. However, 16 participants named an effect that was not indicated in the intervention, but could also be correct, such as "Then you die" or "You dry out". After participating in the intervention, 76% of the participants were able to indicate at least one of the effects mentioned in the intervention. Of these children, almost half were able to indicate more than one effect. For example, "You get a headache" and "You can pass out" were the most common given answers. Eight days after the intervention, these effects are commonly mentioned as well. In total, 16 of 25 participants were able to recall at least one of the effects. All answers pointed towards the negative effects. Even when participants were not able to recall specific effects, answers such as "Bad things" were given. For both questionnaires completed after the intervention, the effects of getting a headache and passing out were the most given answers. This could be due to the emphasis made within the story. When Anna examines the lion, he tells her he has a headache and has just passed out. These two effects are explained by the doctor as well, being the only two effects that have been repeated in the intervention.

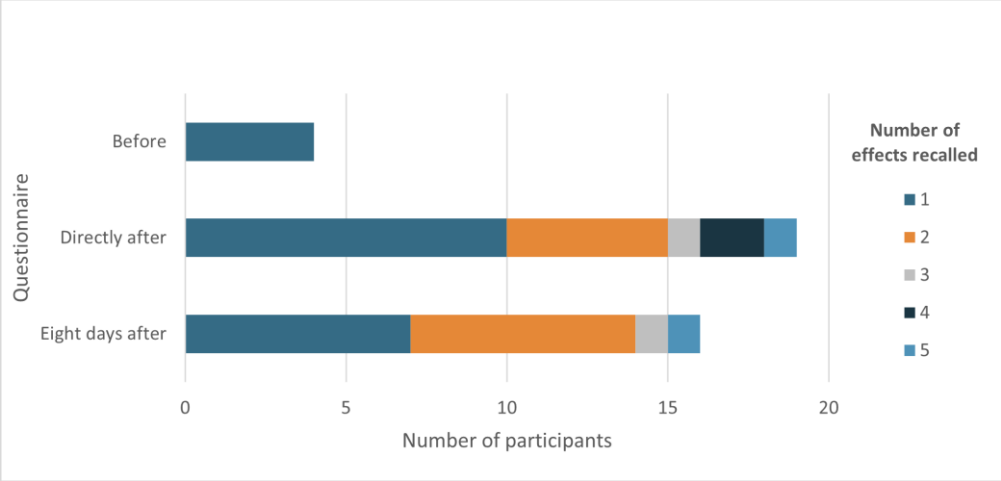

Figure 10. Number of participants that correctly recalled at least one of the effects explained in the intervention, for all three questionnaires.

5. Limitations and recommendations

In this work, we focused on personalising design to improve the effectiveness of the intervention for children. The generalisation of the results is limited because of the sample size and the lack of diversity. All of the participants were Dutch, part of the same school, and aged between 8 and 9. To validate the results and draw more general conclusions, we recommend repeating the study with a larger sample. In addition, investigating the effects in the longer term is beyond this study. Therefore, we can only conclude about the effects of the intervention till eight days after the intervention. Therefore, further research is needed into the effect over the longer term. In addition, the results of the study rely on the children to understand the questions and answer them truthfully. The accuracy with which children report the number of glasses of water they drink per day may vary. Therefore, future work could validate the data using a second source, such as asking the parents to also count the number of glasses their children drink per day. This would confirm that the data is accurate, resulting in more reliable and objective findings. Furthermore, while the design of the persuasive intervention and interactions were personalised to this specific context (i.e., the story, the water glasses as controllers, the game mechanics) and tailored to suit the targeted age group (e.g., the characters, the graphics, the interactions), the content of the intervention was not personalised. In future work, personalised stories, icons, and strategies will be used to further personalise the intervention. Related work shows that personalising persuasive strategies may affect behaviour and attitude change [54,14]. In addition, the intervention had a fixed reading speed, without an option for audio support. Enabling personalisation is recommended to optimize the intervention, since this will provide the most optimal intervention for each participant, thus possibly conveying the information better.

6. Conclusions and future work

This research aimed to change the behaviour, attitude, and knowledge of children towards drinking water. We designed a persuasive intervention and tailored the interactions to the context. Given that persuasive technologies have been shown to be effective in motivating healthy behaviours, we hypothesized that a persuasive intervention personalised to suit the target age group would have a positive significant effect. Our findings suggest that after participating in the intervention, children aged 8 to 9 reports drinking more glasses of water, on average, per day. In addition, they know significantly more about the recommended water intake behaviour and the effects of drinking too little water. Their attitude towards drinking water has changed, showing significant improvement directly after participating in the intervention and a positive trend eight days later. This suggests that the design of the intervention is effective. Our results indicate a possible solution for the water drinking problem among children. To validate the results while taking into account the limitations of generalisation,

reliability of the answers, the effects of the intervention in the longer term and personalisation, future work is recommended. Addition-ally, future work is recommended regarding the use of persuasive principles. The intervention implements five persuasive principles. However, in future work, the effectiveness of these principles should be investigated separately, to determine the individual effect. Furthermore, this study has been conducted among children aged 8 to 9 years old and focused on this age category. Further research should repeat the experiment within other age groups and alter the storyline and game to fit the new participants. The storyline and persuasive principles could be personalised based on individual user characteristics. Future work could also use this approach as an inspiration for research towards other health-related problems among children, such as motivating healthy diets and exercise.

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