

# Keep Brushing! Developing Healthy Oral Hygiene Habits in Young Children with an Interactive Toothbrush

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## ABSTRACT

*Cravy Brush* is an interactive toothbrush attachment that helps young children (3-8 years old) develop a daily habit of brushing teeth. The attachment displays an interactive game that provides real-time visual and auditory feedback. In addition to feedback, *Cravy Brush* also provides virtual rewards when children brush properly. Alarm feature calls for children to brush their teeth twice a day at desired times. We collect background data regarding tooth brushing sessions, which can be presented later on to parents.

In this paper, design and development of *Cravy Brush* and lessons learned are presented. As a starting point, we conducted a pilot test with one child for a week's duration. Feedback from both parents and the child revealed that *Cravy Brush* made the tooth brushing experience more fun and was effective at encouraging the child to brush her teeth regularly for the dentist-recommended two minutes.

## Author Keywords

Serious games; persuasive games; games for health

## INTRODUCTION

Daily preventative dental hygiene habits, such as brushing teeth, are of great importance for people of all ages. When teeth are not taken care of daily, they can develop cavities and decay [1]. Such decay is often painful, and may require dental procedures, which are also painful and stressful for adults and children. Besides the self-confidence of a healthy smile, bad oral health is supposed to be correlated with some serious diseases such as heart attack, though no scientific evidence of direct effect is found yet.

Good oral health is proportional to brushing teeth at the correct frequency, duration and technique [2]. For effective oral hygiene, people of all ages should brush teeth twice a day for two minutes [3]. Unfortunately, in a study conducted in 2009 [4], the average tooth brushing time of

the general population was given as approximately 45 seconds, far less than the recommend two minutes. According to a recent study however, more than half of the children at the age of five do not brush their teeth twice a day and deficits in brushing, such as wrong technique and insufficient duration are observed [5].

To overcome insufficient tooth brushing at childhood, parental supervision while brushing is strongly recommended [6]. In addition, making the process fun by singing a favorite song of children or pretending to play a game is suggested by some front runner oral healthcare brands [7, 8]. Though it can be emotionally satisfying, tracking children's tooth brushing and motivating them by improvised theatricals may incur a burden on parents in the rush of their daily routines. These tooth brushing deficits of children are likely to persist into adulthood [9]. For good dental health that will last for the rest of their lives, children should learn healthy oral hygiene habits as early as possible.

In this paper, we describe the design of *Cravy Brush*, a toothbrush attachment that provides children with an entertaining interactive brushing experience. By making brushing more fun, with the game embedded toothbrush add on, *Cravy Brush* helps young children develop a positive lifelong habit of brushing teeth for the right frequency and duration. Our paper makes the following contributions:

- Design and development of an interactive toothbrush add-on that aims at helping children gain tooth brushing habit.
- Design and implementation of a children's tooth brushing game to make the process more fun for them.
- Parental and children's feedback from the one week pilot test.
- Lessons learned throughout this study, regarding designing interactive game experiences for young children.

## RELATED WORK

Systems that focus on reinforcing tooth-brushing habits exist both in the literature and industry. We first mention related work from academia and then discuss commercial products.

### **Dental Hygiene Systems from Academia**

Chang et al. propose a playful system that encourages children learn correct tooth brushing techniques with the help of a video game [10]. In the game, mirror image of the child's dirty teeth is displayed on a screen and the child tries to clean the virtual teeth by brushing their own teeth. The prototype consists of a cable connected toothbrush equipped with led markers that are tracked by surrounding video cameras to identify tooth brushing motions. Brushing game which incorporates child's brushing strokes is displayed on a monitor in front of the child. The authors' system provided improvement in tooth brushing technique and duration of children according to their user study results. The work provides a complete system with scientific results but its requiring special hardware equipment such as cameras, monitor and LED markers makes the design impractical to use in daily life.

Another intelligent tooth brushing system is proposed by Flagg et al. which caters to elder individuals who may forget brushing their teeth [11]. Aim of the work is to develop a tooth brushing system that will remind and guide the user. Authors developed a vision based tooth brushing system that consists of a bi-color striped toothbrush and web cameras. However, the work suffered from limitations in depth recognition with image processing and needed further improvement to effectively serve as a prompting system.

### **Dental Hygiene Systems from Commercial Entities**

There are many commercial products focusing on making the tooth brushing experience more fun and habitual for children. An example is "Tooth Tunes" by Arm & Hammer Inc. which plays a preloaded song for two minutes when the button on the toothbrush is pressed [12]. The product focuses on encouraging the child to brush their teeth for a complete two minutes. Although it is an innovative product, since the music plays for two minutes and then stops, it makes the reward at the process. In the end, the child does not get any reward, which may turn out to be a discouraging factor for the completion of two minutes. Tooth brushing movements of the children are not incorporated into the brushing experience, the song keeps playing even when the brush is kept still after the button has been pressed.

A popular application for children that is recently released is "Disney Magic Timer" by Oral-B [13]. The application can be downloaded to smartphones or tablets. When started, the application counts down for two minutes and reveals a picture gradually as the time passes. The colorful characters seem spot on to encourage the children but the downside is that there is no mechanism to ensure that the child has been brushing their teeth for the reward to appear, just starting the application is enough. Brushing movements of children are not incorporated into the application.

Another commercial product for children that focuses on completing the two minutes brushing duration is "Brush Buddies Talking" by Ashtel Dental [14]. The product is

designed in the form of different animals talking for two minutes while the child brushes their teeth. Information about effective oral care is given during these talks. At the end, verbal positive feedback is also given to encourage the children. The downside of the product might be considered as focusing on the auditory feedback only, while omitting the visual. Again, brushing movements are not incorporated into the design, pressing the button activates the two minutes talking session.

Though not interactive, another commercial product example we find worth mentioning is Jordan's toothbrushes that are specially designed for children [15]. These toothbrushes are designed in the form of toddler toys in order to encourage children to use them. Although the design of the brushes seem really attractive, only physical form is used for encouragement.

An interactive commercial product for adults is "Oral-B Professional Care Smart Series 5000 with Smart Guide Electric Toothbrush" [16]. Toothbrush has a separate smart guide that can be put onto sink countertop or attached on the wall. Smart guide provides visual information on how much time has spent brushing each four quadrant of the mouth. After the user completes two minutes, a smiley face appears as an appreciation. Janusz et al. performed a study on effectiveness of the mentioned brush [17]. Adults using the smart brush brushed their teeth more thoroughly according to their user study results. As another improvement, users brushed four quadrants of their mouths more evenly in duration. The product uses high technology to sense the brushing movements and give interactive feedback as an upside. But since the display is monochromatic as the product is designed for adults, it may not be encouraging for children who are used to more colorful displays.

All of these mentioned examples have their own merits and contributions. Our work differs in providing an interactive digital game for children that gives real time visual and auditory feedback with a practical invisible product design that does not require any environmental installments. Children can use *Cravy Brush* with their favorite toothbrushes since it is designed as an attachable add-on for any toothbrush. In the video game, there are bacteria that need to be destroyed which provides interactivity and engagement, while making sure that the child completes two minutes brushing time. Child's brushing strokes are recognized with their 3D orientation. Brushing of upper and lower teeth are incorporated into the game in the form of bacteria destroyed. If the child stops brushing, the system recognizes this and responds accordingly to encourage children to keep brushing. We employ a rewarding mechanism to encourage children come back and brush their teeth regularly. Surprise rewards are also employed to increase motivation. *Cravy Brush* can be programmed to call for the child to brush their teeth at desired times of the day, serving as a reminder. Finally, the system captures

tooth brushing data of the children which gives parents the opportunity of reflection and appropriate behavior adjustment afterwards.

### **CRAVY BRUSH**

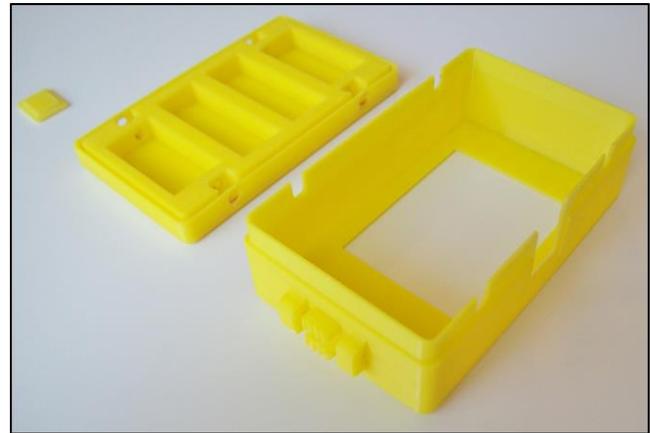
*Cravy Brush* is a small attachment for toothbrushes that features an interactive children’s game on a colored LCD screen and gives auditory feedback via loudspeakers. Our target audience are children of age between three and eight. Currently, high fidelity proof of concept prototype of *Cravy Brush* is built up that consists of a mini smartphone covered with waterproof material and put inside a specially designed 3D printed case. This prototype can be attached to any toothbrush with a flex cuff. A general view of *Cravy Brush* prototype that is attached to two different children’s toothbrushes can be seen in Figure 1.

### **Prototype Design and Implementation**

While designing *Cravy Brush*’s high fidelity proof of concept prototype, emphasis is given on invisibility, compatibility and compactness. Making the prototype invisible means that it does not require any environmental installment and can be used practically without too much effort. The reason behind this is not to repel the user. Compatibility means that the user can use the product with any existing toothbrush. This is important because we do not want to take away any comfort from the children. If they have a favorite toothbrush, they can still keep on using it. Compactness means that the add-on is as small as possible while containing all necessary elements of visual and auditory feedback. The reason behind using a mini smartphone for the prototype is its compactness while providing many technical capabilities such as LCD screen, three axis accelerometer and loudspeakers. Current dimensions of the attachment prototype are 5.7x9.5x3.1 cm. For the final product, a specially designed set of mini display, loudspeakers and embedded batteries will be used. The end product is planned to make a smaller attachment of approximate dimensions of 5.5x3.5x2.0 cm.



**Figure 1. *Cravy Brush* prototype attached to two different children’s toothbrushes. Left: Front view displaying the interactive game. Right: Back view of the case.**



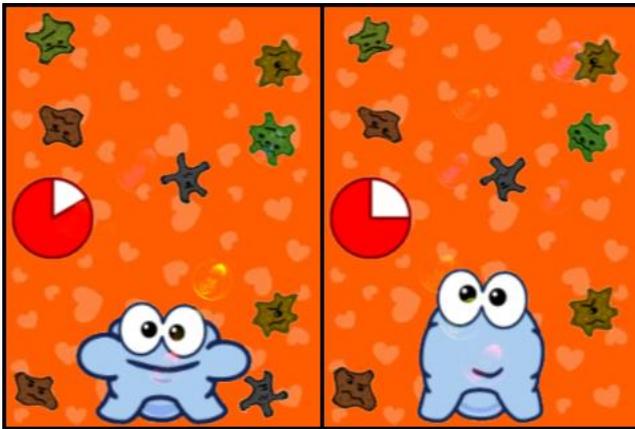
**Figure 2. 3D printed case of *Cravy Brush* prototype to hold the mini mobile phone inside. Left: Charging hole cover. Middle: Bottom part of the case. Right: Top part of the case.**

For the prototype, a case to hold the mini smartphone was designed and produced with a 3D printer. While designing the case, it’s being as small and stable as possible was of great importance. We also tried to keep the design aesthetic and simple, following the guidelines in the work of Consolvo et al. [18]. The case consists of three parts as can be seen in Figure 2. Two parts hold the phone and the third part is to enable charging of the phone inside. At the bottom of the case, there are bridge holes for flex cuff to pass. This way, *Cravy Brush* can be attached to a toothbrush tightly. In order to prevent turning of the toothbrush in its own axis inside the flex cuff, a saw toothed offset is added to the middle of these bridges.

After 3D printing, the model is decorated with stickers to give it an attractive look for children. Before the phone is put into the case, it is wrapped with waterproof plastic as a precaution layer. After several trials, the angle of attachment that enabled the child to best see *Cravy* while brushing turned out to be 90 degrees upward at the back of the brush facing inside, as can be seen in Figure 1.

### **Game Design and Implementation**

In order to help children develop regular tooth brushing behavior for the right duration, a children’s game is designed that features a cute monster called *Cravy*. *Cravy* eats bacteria. In order to make *Cravy* eat bacteria, the child has to brush their teeth. Twice a day, *Cravy* craves for bacteria and calls for the child to help him eat them by brushing their teeth. Two general screenshots of the game which shows *Cravy*, bacteria, timer and foam particles are presented in Figure 3. The child has to feed *Cravy* two times a day. The idea is to create a bond between the child and the character besides providing them a game, so that they would keep coming back to feed it.



**Figure 3. Screenshots of the game showing *Cravy* chewing, bacteria around, clock and foam particles. Left: 20 seconds have passed since beginning of the brushing session. Right: 30 seconds have passed since beginning of the brushing session.**

There are 10 bacteria at each game session, five at the bottom and five at the top. For every 10 seconds of upper and lower teeth brushing, a bacteria at the corresponding side is eaten by *Cravy*. The reason behind that is to make the child brush their upper and lower teeth evenly in duration, one minute each. For good dental health, it is suggested to brush upper and lower teeth for one minute [19]. When the brush is turned upside down, *Cravy* also falls down to the other side to give the child a sense of rotation and engagement. It is known that as the user's actions affect the gameplay, they are more engaged into games [20]. Hence, we tried to make the children's movements affect the gameplay while avoiding overwhelming them with too many variables. User's tooth brushing strokes with their 3D orientation are recognized using the data coming from the three axes accelerometer inside the smart phone. If the maximum difference between the acceleration values of any axis exceeds a threshold value over a predefined period of one second, then brushing is recognized.

The enemy bacteria characters in the game can also be seen as a form of data abstraction as proposed by Consolvo et al. [18]. They tell the children how much time they need to spend brushing their upper and lower teeth in an attractive way. 10 seconds buffer is added for brushing each part so that the child will get enough time to defeat all of the enemies without getting stressed out. But on the other hand, we also wanted to make sure that the child brushes their teeth for the proper duration of two minutes. To ensure that, the resulting screen of the game showing rewards appears only after the child brushes for 120 seconds. So even if the child destroys all of the bacteria in a perfect 100 seconds, they will have to brush until it sums up to 120 seconds to be able to see the resulting screen. There is a child friendly visual timer on the screen showing how much time remains as a form of feedback, shown in Figure 3.

### Feedback and Rewards

In the resulting screen, stars are presented to provide positive feedback based on the child's tooth brushing performance. Three stars are given for defeating all of the bacteria and brushing for a complete two minutes. Two stars are given for brushing for two minutes but having any number of bacteria remaining on the screen. Finally, one star is given for not completing two minutes brushing time. Rewarding system is designed to encourage children at first place. So even if they fail to complete the proper brushing time, no punishment is used, instead a star is given to encourage them. The idea behind this approach is to motivate them to keep trying by using a positive reinforcement as suggested in [18]. Other than the stars, there is a badge visual that appears only if the children have brushed their teeth in the previous 12 hours period. The reason for this is to make the child keep brushing regularly in order to see the badge on the screen and feel a sense of accomplishment. Our final type of reward is rare items that are in the form of attractive visuals for children such as princess crown, balloon and cake slice. Rare items appear with a 20% probability if the child got three stars and the badge at the current brushing session, meaning that they had brushed their teeth in the previous 12 hours period and they had brushed their teeth for two minutes in the current session, giving upper and lower teeth one minute each approximately. It is shown that unexpected rewards provide more motivation in individuals as compared to expected ones [21, 22]. Hence, these rare items are designed to serve as a variable to surprise the children. All of the mentioned reward types can be seen in Figure 4. After the brushing is completed, *Cravy* enters into score state until the next brushing session. While in the score state, *Cravy* celebrates by jumping continuously with accompanying sparkle particles. If there are remaining bacteria, they also remain on the screen as a form of feedback. Stars, badge and rare items are kept at the center of the screen.



**Figure 4. Screenshot of the game showing the resulting screen. Left: Rare item of cake slice. Middle: Three stars meaning that the child destroyed all of the bacteria and brushed for two minutes. Right: Badge meaning that the child brushed their teeth in the previous 12 hours period.**

The reason behind this long score state is to give the child opportunity of reflection on their performance. *Cravy* still responds to children movements in the score state. If the child turns the brush upside down, *Cravy* also jumps onto the other side of the screen, continuing jumping there.

To give a clear understanding of different game states, a flowchart which summarizes each possible state of the game and their relations to each other is presented in Figure 5. In the idle state, the game is ready for playing. Two times a day at the predetermined times, *Cravy Brush* enters into the reminder state in which *Cravy* calls for the child to brush their teeth. When the child starts brushing, it enters into the brushing state and the interactive game of feeding *Cravy* with destroyed bacteria begins. If the child stops brushing during the game, warning state gets activated. In the warning state, background music is stopped, *Cravy* stops chewing and gives verbal prompt to the child to keep brushing. Then, if the child continues brushing, brushing state gets reactivated until two minutes time is completed. If the child does not continue brushing after stopped once or completes two minutes brushing time successfully, score state gets activated. Score state features rewards and *Cravy* celebrating the previous session. *Cravy Brush* remains in the score state for a programmable duration that is currently set to 12 hours. After that, the circle is completed by the activation of idle state, meaning that *Cravy* is ready for another brushing session.

#### Audio Effects and Voices

In the game, sound effects play when bacteria gets destroyed and during the celebration at the end. If the child stops brushing, *Cravy* gives verbal feedback to make them continue brushing (“Keep Brushing!”). Cheerful and upbeat background music is played as long as the child keeps brushing, to make the brushing process more fun. If the child stops brushing, the music stops. The stopped music communicates that the child should start brushing again.

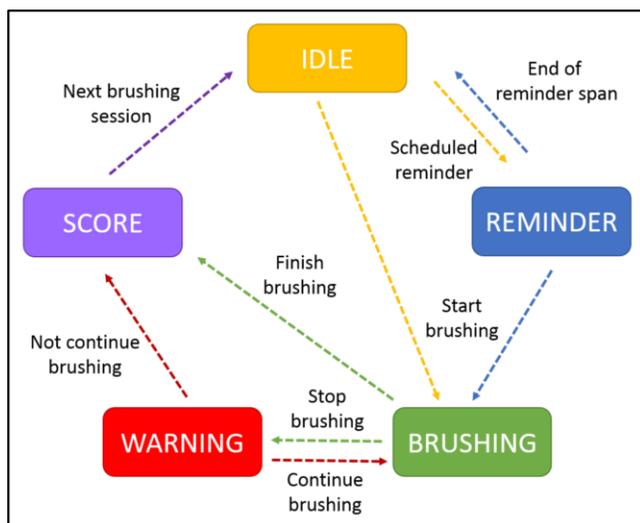


Figure 5. Flowchart presenting each possible game state and their relations to each other.

*Cravy Brush* has an alarm feature to remind the child to brush their teeth at the programmed times of the day. As Fogg states in his behavior model for persuasive design [23], individuals may need to be triggered to perform a desired action. Timing of the trigger is also important for activities that need to take place at specified times of the day such as tooth brushing. When in the alarm mode, *Cravy* calls out for the child to brush their teeth. Instead of using an alarm sound solely, *Cravy* verbally asks the child for help. The idea behind that is to create a more attractive form of trigger for children.

#### Data Collection

Another important feature of *Cravy Brush* prototype is automated background data collection. Currently, we are collecting data in raw format which can be presented to the parents after being edited into an easily readable form. This can enable the parents to see when and for how long their children brushed their teeth. Unintentionally, people have a tendency to significantly overestimate the time they brush their teeth as a recent study by Terezhalmay et al. reveals [24]. Data collection is a helpful way of being aware of actual times spent on activities as proven by various studies [25, 26]. With automated data collection, parents can help their children make necessary adjustments on their tooth brushing behaviors. This reduces unintentional overestimation errors. For these reasons, in the end product, an automated data collection user interface is planned to be implemented.

#### USER EVALUATION

A female, four year old child used the *Cravy Brush* prototype for a week’s duration. Before conducting the user study, we decorated the casing with stickers of the child’s specific interests to increase the prototype’s attractiveness. Her parents used to brush her teeth every day before the user study, hence she had no prior self tooth brushing experience. For the testing period, she brushed her teeth with *Cravy Brush* every day. Her parents video recorded the brushing sessions and provided us with them. At the end of the study, interviews were conducted with parents and the child which involved answering some qualitative questions and providing feedback on the brushing experience.

#### Parental Feedback

Parents of the testing child were pleased with *Cravy Brush* overall. They said that their child was excited about using *Cravy Brush* during the whole testing duration. They also stated that they would want their child to use such a product every day. Her parents said that after trying *Cravy Brush* she started to brush her teeth on her own, which helped her to become a bit more independent. They also said that this achievement made the child excited and happy.

Although it was not designed as a training product, *Cravy Brush* helped the child learn how to brush her teeth on her own, for the first time, without getting any parental help. The parents stated that after stopping using the *Cravy Brush*

prototype, the child still brushed her teeth by herself without any help.

Another feedback of the parents was that the prototype's being a bit heavy for little children. Although a mini cell phone of 120 grams weight is used for the prototype, it still challenged the child to hold the brush comfortably with one hand sometimes. Another negative feedback was regarding the placement of the display. Parents informed us that the child held the brush in a weird way while trying to see what was happening on the screen. This may degrade the brushing quality which is antipodal to the whole idea behind the study.

A positive feedback was on how responsive the child was to the *Cravy* character. Every time *Cravy* talked, she consistently responded, talking to him as if he was a real character, as suggested by Isbister and Nass [27]. Regarding the rewarding system, parents said that the child was excited and motivated about getting three stars. At her first few trials, she did not manage to get three stars, which disappointed her a bit. But then, she consistently started to get three stars, which made her happy. Other than the three stars, she also looked for the badge icon on the screen after brushing, getting happy as she saw it. She was also disturbed by the remaining germs, if any, asking why they were still there after the brushing was complete. We consider these as positive indicators of the successful aspects of our design.

Other than using it as a toothbrush, the child continued playing with *Cravy Brush* after brushing her teeth. She played with *Cravy* as if it were another doll in her collection. *Cravy* "talked" with other dolls, "walked" up and down the dollhouse stairs and done many more imaginative things.

At the first few days of user study when the child was not so comfortable with brushing her own teeth, she picked up *Cravy* without parents' prompting and shook it to hear the in game music and sounds. After getting comfortable with brushing her teeth on her own, one day while sitting in the living room the child grabbed *Cravy Brush* and started brushing her teeth without any toothpaste. These use cases show us that the child perceives tooth brushing experience with *Cravy* as a game rather than a necessary daily routine.

Parents stated that she liked being taped while brushing, asking them to take videos of her while brushing her teeth or doing other activities during the day. She associated being video recorded with the act of tooth brushing using *Cravy Brush*. This feedback gave us the idea of turning the product into an augmented reality experience which shows the child and interactive characters together on the display or as a projection, as a future possible improvement.

Parents' final feedback was about the child's general bed time routine. They said that before the user study, the child had a tendency to drag out the bedtime process consisting of her hygienic care and story reading, to stay up longer and

play. But they happily said that this did not happen after using the *Cravy Brush* prototype since the child was too excited to use it at nights. They stated that it helped them to make the bed time a little bit easier. This feedback gave us the idea of expanding *Cravy Brush* as an entire bed time routine companion to help parents in their child's bed time process, as a future development.

### **Child's Feedback**

We requested the parents to ask four simple questions to their child for us, after completing the user study. They asked these questions to the child and video recorded her answers. In addition to giving each question explanatory answers, the child provided additional feedback also. First question was "*What did you like about Cravy?*" The child's answer was "*How he lets me know about all of the stuff when I am done and then I know when I am done.*" The second question was "*Would you like to use Cravy every day?*" The child answered "*Yeah! Cravy is cool.*" The third question was "*Do you like brushing your teeth with Cravy?*" and the child quickly answered "*Yeah.*" The fourth and final question was "*Is there something you don't like about Cravy?*" The child's answer was "*Um, no. There isn't anything I don't like.*" As additional feedback the child also said that she liked the colors of *Cravy* and the stickers on it. As the parent asked her if she would like *Cravy* as much without the stickers on it, she said that she likes it with the stickers on it.

### **LESSONS LEARNED**

In this section, we would like to share lessons we have learned throughout this study from its beginning up until now, considering that they might help other researchers in their studies regarding child friendly interactive designs involving games.

First of all, we learned that when designing games for children, their testing sessions can give developers ideas they have never thought of before. So, starting the testing early in the process might help more. In our case the most obvious example we never thought of before was the child's playing with the prototype as a normal toy outside of the tooth brushing sessions.

Turning the prototype into something attractive for the child using different colors and decorative aids like stickers helped a lot in our case. The child embraced the prototype quickly although it was too plain in its outer shape form as compared to other commercial children's products. Colorful particles displayed in the game also attracted the child's attention.

During the development phase, we have adjusted the parameters by self-trials, pretending to brush like a child. But when the prototype is given to the child, it remained ineffective since it did not recognize her tiny brush strokes. The child was brushing her teeth with really little strokes and at a small pace. So, the prototype was giving too many prompts, since it was not recognizing any change in

movement above the specified threshold. It was a discouraging factor for the child getting prompts to keep brushing while she was already brushing. We quickly made an additional calibration according to our observations from the videos and in this calibration, parameter values were given considerably too small as compared to our previous calibrations. The recalibration solved false prompt giving problem and we learnt that when designing games for little children, pretending to play like them as adults remains ineffective. Making them try the prototype as early as possible and adjusting the parameters accordingly can be a more clever way which would save time.

We saw that an interactive companion encourages the child to fulfill her daily tooth brushing duty in a fun way. The game helped spending two minutes time without getting bored. The child was motivated to destroy all the bacteria and see the resulting screen, which ensured that she brushed for two minutes. We observed that providing the child interactive small missions of destroying bacteria one at a time kept her busy while brushing and resulted in more proper duration of time spent. We believe that such interactive companions featuring games can be effectively used to reinforce daily regular health routines that are not normally so fun to fulfill. The child-avatar bond can extend outside the health applications into other playful interactions that are not related to the health behavior of interest. Children treat the avatar as another toy in their collection. This also implies that a child's existing bonds with toys, dolls, and action figures could be leveraged in health apps and games.

We designed *Cravy Brush* software to be always on. It allows the child to brush their teeth two times a day. After the brushing sessions, it remains in the score state which features *Cravy* celebrating. This came with a more frequently charging burden for the parents but also resulted in the child's playing with the prototype throughout the day. So, we think that while designing products for children, keeping them accessible any time they want to play with, even if at a more restricted state, is important to make the bond between the child and the product stronger.

While designing it, we wanted the *Cravy Brush* to be attached to the tooth brush instead of standing still somewhere else. The reason behind that was to encourage the child to embrace the tooth brush, associating it with playing a video game. However, this resulted in some difficulties during brushing since the child was curious about what was going on in the screen and holding the brush in an orientation that gave her a proper viewing angle. This is a potential degrading factor for tooth brushing quality, which is not desirable. But as an advantage on the other hand, it resulted in the child's playing with the toothbrush on which *Cravy Brush* was attached as if it was one of her other toys.

As another lesson learned, making the character talk was more important than we gave credit for during the design.

The child tirelessly gave answers to the character when *Cravy* prompted her to keep brushing, even though it was not a question at all. We think that while designing products for little children, making characters talk can considerably increase the child's immersion and make the experience more interactive and fun for them. Young children can form powerful bonds with interactive avatars that communicate verbally and respond to a child's real-world behavior (in our case, the motion of a toothbrush.) The formation of this child-avatar bond is likely critical to the development of new health habits in young children. Health app and game developers targeting this population should consider integrating avatars with these characteristics.

As a final insight, young children have little experience with health behaviors, and thus doing these behaviors correctly (in some cases, for the first time) requires the child to focus entirely on performing the behavior. An interactive tool like *Cravy Brush* may in fact distract the child and detract from performing the behavior correctly. Careful thought is needed to ensure the design of health behavior apps and games for young children manage their attention properly.

#### **CONCLUSION AND FUTURE WORK**

In this paper, design and development of *Cravy Brush*, an interactive tooth brush attachment for children, is presented. The aim of the study is to help children gain tooth brushing habit for the right frequency and duration by making the tooth brushing experience more fun for them. Results of the user study conducted with a four years old child revealed that *Cravy Brush* was effective in these targeted aims. Feedback provided at the end of the user study indicated that there are many features of the prototype that need to be improved, which gave us clear directions for future work.

As future improvements, we are planning to work on a lighter prototype which may be attached to somewhere other than the toothbrush. Instead of solely focusing on tooth brushing, we want the improved version to cater to many more bedtime routines such as taking a bath, getting dressed, flossing, brushing teeth, brushing hair, reading a story, using the potty, getting and staying in bed. This way, we believe that it will serve as a helpful small assistant for parents, which leads the children through the entire bedtime routine. In the future versions, it's being designed as a mobile playable toy is important to enable the child play with it throughout the day as one of their other normal toys. Making the in game animations more dynamic and adding more talking to characters would help making the experience more fun and interactive for children. A parental user interface for data reviewing is also planned to be implemented, considering several advantages of reflection on the collected self-data. We are also considering to build up an augmented reality version, featuring the child and the virtual characters overlaid.

Until now, we have tested the prototype with one child for a long duration. For an effective and generalizable user study,

number of participants should be increased. So in the future, we are planning to test the prototype with more children to discover even more ways to improve and suit *Cravy Brush* to the little children's needs.

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