Ergonomics In Design, Vol. 77, 2023, 490–494
https://doi.org/10.54941/ahfe1003408

Design of Spherical Handle for Children's Electric Toothbrush in Order to Improve Grip Comfort and Stability

Xinyue Zhuang, Tiancong Wang, Zixuan Zhang, and Haining Wang

Industrial Design, Hunan University, China

ABSTRACT

Children have a weaker grip compared to adults, but the electric toothbrushes available on the market for children currently do not have a design that specifically targets their grip needs. Thus, this study aims to investigate the characteristics of children's gripping styles and design an electric toothbrush that caters to the needs of both children and parents. The research team conducted literature research and interviews to identify the pain points in the use of children's toothbrushes, extracted design requirements, and proposed a solution with a spherical grip. A corresponding model was created based on the proposed design solution, and users were allowed to test it out and provide feedback. Finally, a children's electric toothbrush was developed that satisfies the expectations and needs of both target groups. This study provides a new idea and a reference for designing appliances that cater to children's grip needs.

Keywords: Children's products, Electric toothbrush handle, Grip style

INTRODUCTION

As technology advances, the market is flooded with a variety of electric toothbrushes, prompting many parents to consider purchasing them for their children. Studies have suggested that electric toothbrushes may be more effective in cleaning children's teeth than manual brushing. However, upon researching and analyzing the children's electric toothbrushes available, we found that many of them are simply adult electric toothbrushes scaled down in size, without taking into account children's grip strength and usage habits.

Therefore, in order to address this issue, we will conduct a literature review and specific design studies to explore how to create an electric toothbrush that is truly tailored to children's grip strength and usage habits.

EXISTING PRODUCT ANALYSIS

We examined the existing designs of children's electric toothbrushes, with a focus on the brush handle and grip, and found that most available options are simply scaled-down versions of adult toothbrushes without specific consideration for children's grip ability. There are some designs that feature a cupped grip or increased thickness, but their effectiveness is limited. Additionally, we analyzed and integrated various technologies including pressure

Technology Name	Technical Analysis	Design Applications
Pressure sensors	By utilizing a pressure chip, the resistance value changes when pressure is exerted on the diaphragm, resulting in a linear output signal that is proportional to the amount of pressure applied.	When applied to the toothbrush, this technology detects whether the pressure applied to the teeth is appropriate. If the pressure is too high, the system can provide an indication.
Acceleration sensor	This sensor operates on the same principle as a gravity sensor, and it determines the acceleration direction in three dimensions. Although it consumes low power, its accuracy is relatively low.	The sensor can be utilized in toothbrushes to accurately record the number of times the teeth are brushed, and to motivate children to brush their teeth more effectively by enabling them to clock in their brushing routine.
Gravity sensors	The gravity sensor includes an internal weight that is integrated with a piezoelectric sheet. This sensor measures the magnitude of the voltage generated in two orthogonal directions to calculate the horizontal square and determine the orientation of the toothbrush.	The gravity sensor can be incorporated into toothbrush design to detect the horizontal direction and adjust the angle for optimal cleaning.
Gyroscope	Gyroscopes are able to measure angular velocity along one or multiple axes of motion, and are an ideal technology to complement the functionality of accelerometers.	If combined with two sensors, an accelerometer and a gyroscope, it can track and capture the complete movement in 3D space. This provides the end user with a more realistic user experience, as well as an accurate navigation system and other advanced features.

sensors, acceleration sensors, gravity sensors, and gyroscopes, and explored how to apply them in a reasonable and scientific manner during the design process.

After analyzing and integrating existing technology, we discovered that current technology can already provide effective adjustment and assistance for children's brushing. As a result, the most critical aspect of designing a children's electric toothbrush is to ensure that it has an ergonomic grip that enables children to comfortably and securely hold the vibrating toothbrush during use.

USER NEEDS ANALYSIS

During our research, we observed that children's toothbrushes are not only used by children but also by parents. Therefore, we considered the different needs of both parents and children. Parents prioritize safety, cleanliness, and

comfort when choosing an electric toothbrush, while children focus on the attractiveness and comfort of the toothbrush. To create a successful design, we needed to create a toothbrush that satisfied both parties.

Through our research, we discovered that the design of children's toothbrush handles is still in its infancy. The current toothbrush handle design is not user-friendly for children due to their limited hand grip ability. Parents are concerned about their children's ability to brush their teeth effectively and the resistance and difficulty in developing brushing habits. By integrating these pain points, we focused on designing a grip that caters to children's needs while addressing the concerns of parents through information feedback, resistance elimination, and habit formation.

DESIGN

Design Objectives

Based on our research and data analysis, we have established five design goals for our product: to make tooth brushing appealing to children, to ensure comfort while brushing, to promote cleanliness, to develop healthy habits, and to provide peace of mind for parents. We have developed specific solutions to address each of these goals.

Design Options

The issue with electric toothbrushes for children available in the market is that they are not sufficiently comfortable for children to grip, and this discomfort may lead to reduced safety and cleanliness. Thus, our focus is on the goal of "comfortable brushing." The design of the electric toothbrush is mainly divided into two parts: the brush handle and the brush head. In our research, we found that the most natural grip for children is a spherical grip, based on literature that suggests that the human palm muscles and palm form a groove that can reduce pressure on the palm. Additionally, we observed that when children use a toothbrush, their palm and grip positions are typically close together, which increases contact surface and friction, reducing pressure and leading to a more relaxed and comfortable experience. For the brush head, we used national standards and oral measurement data to determine the most suitable size for children's mouths and teeth.

Modeling

Once we had established the "spherical grip" as our main design element, we began the process of modeling and verification. We started with a sketch model, which we created in adult size to allow the designer to gain a better understanding of the grip's features and compare them to their own experience. After experimenting with a variety of brush handle shapes, we were able to determine a shape that was more comfortable and better suited to the needs of children. We made minor adjustments to the length and width ratio based on comparisons between different designs.

To gain a better understanding of the size of children's palms in different age groups, we reviewed literature and conducted hands-on research. We

asked children between the ages of three and six to make handprints on an electronic hand-printing board, then created molds of their palms using ultra-light clay and marked key points for measurement. We then scaled the models to adult size to facilitate the experience and feedback of the design team.

Modeling Verification

We selected an appropriate age group of children, observed their subconscious behavior while using the model, and verified if the modeling guidance achieved the desired effect. We provided the children with the design sketch model and a commercially available electric toothbrush to hold at the same time, and asked them to simulate the posture they used while brushing their teeth with an electric toothbrush to compare the grip comfort. We collected their feedback and experience. Additionally, we asked parents to hold the adult-size model for a similar experience and comparison.

Following the experience, the children generally found the novel toothbrush shape more interesting and expressed a willingness to use it. They found the spherical grip more comfortable and easier to hold than the normal grip, and parents also found it more effortless to grip. We also had the children compare models with slight differences in the length and width ratio of the spherical grip, analyzed the most suitable modeling ratio, refined the model, and established the final shape by considering accessibility, hand-fit, and overall fit.

Various shapes and scales of models

Children's comparative experience with models

Model verification of the final shape

Experiment content	Results
Observe how children subconsciously use the spherical grip model after they get it	Children can follow the shape to guide the correct grip.
Collect children's experience and feedback on the use of ball grips	1. Feel new and interesting 2. Considered easier to grip than traditional brush handles
Adjust the shape of the clay grip in real time based on feedback, and compare children's experience and feedback on different spherical grips with slight differences in proportions	Find the most suitable size ratio
Conducting accessibility, fit, and fit analysis	All in line with expectations
Collect feedback from parents on ball grips (adult size)	Parents find it easier to grip than regular brush handles

CONCLUSION

This paper examines the design of electric toothbrushes for children, with a focus on creating a grip that is more comfortable for children. The study takes into account both the experiences of children and their parents and provides insights into how to design products that are suitable for both groups. Through usability testing, the effectiveness and practicality of the spherical grip design were confirmed, providing new inspiration and guidance for the design of children's appliances that require a comfortable grip.