

Development of Ropot, Traffic Safety Advice Robot

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ABSTRACT

In Japan, seven-year-olds experience an exceptionally high number of pedestrian accidents. To address this, the authors developed a traffic safety advice robot, Ropot, to assist the teaching of traffic safety to children in the lower grades of elementary school.

Ropot has educational functions and receptive functions. In particular, three of the educational functions, known as “check point remind,” “backward check remind,” and “check point result review function,” have not been found in any other device up to now.

To develop these functions, the authors used a global navigation satellite system with high-precision positioning and millimeter wave radar with good environmental robustness. These functions are contained within a partner design that is appealing to children, which enhances the receptive functions.

At an educational trade fair and proving tests, children, their guardians, and school personnel responded positively to the educational and receptive functions, and the effectiveness of Ropot was confirmed.

1. Introduction

The number of traffic accidents has fallen in recent years thanks to the spread of preventive safety technology, establishment of laws, and stricter observance of the rules by drivers and pedestrians. However, an exceptionally high number of seven-year-olds suffer casualties from pedestrian traffic accidents in Japan, a phenomenon sometimes called “the devil’s seven” (Fig. 1)⁽¹⁾. This is the age when children are still mentally and physically immature but are starting to commute to and from school without a guardian. In fact, accidents while commuting to and from school are the most common type (Fig. 2)⁽²⁾.

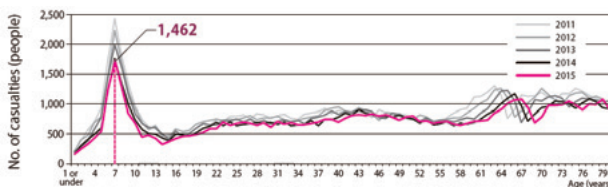


Fig. 1 No. of casualties from pedestrian traffic accidents (2011-2015)

Honda’s 2030 Vision Statement says that we “will strive to become a company that leads efforts to realize a...collision-free mobile society”⁽³⁾. Specifically, “to realize a collision-free society...Honda is pursuing safety in view of three components of safety-human ability, mobility performance, and the traffic ecosystem”⁽⁴⁾ (Fig. 3)⁽⁵⁾.

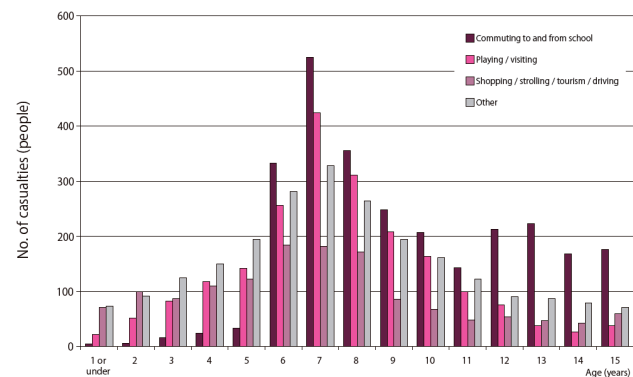


Fig. 2 No. of casualties from pedestrian traffic accidents by trip purpose (2015)

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The reference point for traffic safety is humans. In order to increase human ability, Honda too is providing a variety of traffic safety education before and after the age when children start attending school. However, because of their behavioral characteristics, children of that age are easily distracted by things other than traffic safety. Instead of paying attention to cars, for example, they run after friends who are close by and talk with them. The authors of this paper focused on this point. They decided to develop a traffic safety advice robot (below, “Ropot”) as a system to supplement traffic safety education by reminding children on the spot to take safety check actions, which they otherwise tend to forget. Ropot consists of the main device (“Ropot device”), the cloud, and a smartphone application.

This report narrows the focus to commuting to and from school, which is the setting with the most accident factors. It describes how the authors developed Ropot, how they determined the educational functions and receptive functions, how they implemented them (including the design) in Ropot, and how they confirmed the actual effectiveness.



Fig. 3 Enhancing joy that comes with freedom of mobility while pursuing zero collisions

2. Functions Required of Ropot

2.1. Educational Point of View: Assistance to Confirm Traffic Safety

The authors considered which functions are necessary to assist traffic safety education targeting seven-year-old children.

They began by studying children’s biological cognitive abilities. Dr. Stina C. Sandels found that, compared to adults, children are less able to see the movement of things with their peripheral vision⁽⁶⁾. Moreover, six-year-old children (who are nearly the age of those studied here) have an average horizontal visual field of about 90° and average vertical visual field of about 70°, both of which are more limited than those of adults (150° and 120°, respectively)⁽⁷⁾. Children of this age are also rather short, so their line of vision is low. In addition, compared to adults, children have less perceptual ability to determine where a sound comes from (sound localization), according to Sugita et al.⁽⁸⁾, and are less likely to notice approaching vehicles that are outside their visual field.

The authors next surveyed the behavioral tendencies of children in a traffic environment. According to Renge et al., there are a number of issues to be addressed. For example, children tend to run forward and running makes it more challenging for them to check to their right and left, so even if a car comes, it is hard for a child to stop in time and drivers, even if they do notice the child, find it a challenge to respond⁽⁹⁾. Therefore, it is important for children to come to a full stop and to move their heads to view the scene with a wider visual field.

Next, the authors studied the characteristics of traffic accidents involving seven-year-olds. According to the Institute for Traffic Accident Research and Data Analysis, in fiscal year 2015, commuting to and from school was the purpose of the trip in 38% of cases of casualties to elementary school first-graders (seven-year-olds), the cause of the accident was rushing into the road or crossing the road at other than a pedestrian crossing in about 40% of cases, and the accident happened at or close to an intersection in about 58% of cases⁽¹⁰⁾.

Based on these facts, the authors decided it would be useful to have a function that encourages children to stop temporarily to confirm traffic safety, particularly when they approach locations that require a safety check, such as intersections when children are commuting to and from school (“check points”), and when a car approaches from behind, which tends to be outside a child’s visual field.

2.2. Educational Point of View: Assistance to Repeated Education

The authors believed that to help children establish a habit of stopping to confirm traffic safety, it would be useful to have not only a function that encourages them to stop but also a function that assists in the establishment of the habit of stopping. For that reason, the authors considered methods for developing the habit of stopping in children.

According to Renge et al., police officers and traffic guides often directly provide traffic education in Japan, but by the nature of children, it is important for those already close to them, namely their guardians and teachers, to teach the children themselves⁽¹¹⁾. Also, according to the Institute for Traffic Accident Research and Data Analysis, to change

children's behavior, it is necessary to instruct children repeatedly over some period of time. Another effective way to teach children is for guardians and children to walk the school commuting route together so the guardian can assess the child's development while teaching specific lessons⁽¹⁰⁾. Based on these, the authors concluded that repeated instruction by a guardian as the child grows would be an effective way to establish a habit in the child of stopping to confirm traffic safety.

Realistically, however, it would be challenging for guardians to walk the school route with their children every day. The authors therefore concluded that children could be repeatedly educated as they grow if a guardian provides the child's first traffic safety education and further traffic safety education as the child grows, while a device provides repeated reminders during the child's daily commute to help the child recall what they learned from their guardian and keeps a record of the child's stopping to confirm traffic safety.

To enable the device to play this role, it was decided to design its basic structure so that it could be worn on the child's body. Each day, the child would wear the device, which would give reminders and keep records. The function that repeatedly encourages the child to stop at check points is called check point remind, while the function that repeatedly encourages the child to stop for vehicles approaching from behind is called backward check remind. The function that records the child's behavior and provides a safety confirmation track record to the guardian and child is called the check point result review function.

2.3. Receptive Point of View: A Partner That Teaches and Watches over the Child

Children, guardians, and schools need to be receptive to the Ropot device if children are to wear it during their daily commutes to and from school.

First, if the child is to wear it, the device has to be compact and lightweight enough so it is not a burden to the child during the commute. So to make sure the child would want to wear the device every day, the authors considered the kind of character that the hero of an animated program might carry on its shoulder. There are many animated works that have a character like this. Such a character acts together with the hero. It is like a partner who stays with the hero, constantly watching over them. The authors considered these things as they aimed to create a small partner that would sit on the child's shoulder (Fig. 4). This became the partner design.

Next, to encourage children's guardians to be receptive to Ropot, the authors conducted a web-based survey of guardians across Japan who have children in elementary school. The survey revealed that guardians want to be able to check on their commuting children (learn their current location, be notified when they arrive or depart, etc.) in real time. The authors decided that to do this, guardians would need an application on their smartphone or other

device. The application would have functions capable of confirming the child's current location and departure and arrival. The survey also showed that guardians want to take some responsibility for their children's education and that entrusting traffic safety education to guardians responds to the guardians' eagerness to participate in education.

Finally, elementary schools would need to be receptive to their students bringing the Ropot devices to school so that the children could use them every day on their commutes. This would require a function that partially limits the functions of the Ropot device while at school, so that the children would not use it as a toy during classes and the like. This is called the silent function.

2.4. Required Functions

Following is a description of the basic user experiences and necessary functions as based on the above considerations.

- (1) On the actual school commuting route, the guardian teaches the child the check points and how to confirm traffic safety at them and how to confirm traffic safety in respect to approaching vehicles.
- (2) Using the application, the guardian registers check points to the cloud.
- (3) For the daily commute, the child puts the Ropot device, their "commuting partner," on their body (partner design) and leaves home. The guardian's smartphone receives a departure notification from the cloud (departure notification function).
- (4) As the child approaches a check point, the Ropot device reminds the child to pay attention (check point remind function). The child remembers their guardian's lessons about confirming traffic safety and confirms it.
- (5) When a vehicle approaches from behind, the Ropot device reminds the child to pay attention (backward check remind function). The child remembers their



Fig. 4 Concept of Ropot device in first grade of elementary school

guardian's lessons about confirming traffic safety and confirms it.

- (6) The guardian confirms the child's current location, etc. through the application (current location confirmation function).
- (7) The child arrives at school. The guardian's smartphone receives an arrival notification from the cloud (arrival notification function).
- (8) At school, the Ropot device's functions are automatically limited (silent function).
- (9) The child leaves school, in a process similar to (3) to (7) above.
- (10) After the child returns home, the guardian and child look at the record of stopping to confirm traffic safety while reviewing the child's traffic safety (check point result review function).
- (11) As steps (3) to (10) are repeated, the child develops a habit of taking safety check actions.

Table 1 lists the relationship between points of view and functions required of Ropot as determined by the examination in this chapter. The next chapters introduce Ropot based on the points of view and functions listed in Table 1.

Table 1 Relationship between points of view and functions of Ropot

Point of view	Functions
Educational	Check point remind Backward check remind Check point result review
Social receptivity	Partner design Departure/arrival notification Current location confirmation Silent mode

3. Implementation in Ropot

3.1. Ropot System

3.1.1. Ropot system configuration

Ropot consists of the Ropot device, the cloud, and a smartphone application. Through the application, the school's location and check points are registered to the cloud. The Ropot device obtains that information and activates the check point remind function (Fig. 5).

3.1.2. Ropot device

To use the Ropot device, children in the lower grades of elementary school wear it on their school backpacks (randoseru). The device has a remind function to encourage traffic safety and a function that uploads to the cloud location information and a route history of every stop the child made to confirm traffic safety at check points. Figure 6 shows the hardware configuration and Table 2 the major specifications.

Table 2 Specification of Ropot device

Item	Specification
Size (L × W × H) ^{*1} (mm)	81 × 53 × 59
Mass ^{*1} (g)	170
Continuous operation time (h)	3.5
GNSS receivable signals	GPS QZSS L1C/A, L1S
Data communication system	LTE Cat-M1
Millimeter wave radar frequency band (GHz)	76-77
Charging connector	USB Type-C
Dust-proof/drip-proof performance	Equivalent to IP44

^{*1} Except for attachment part

The Ropot device uses a lithium-ion battery as its power supply. It consists of a CPU, global navigation satellite system (GNSS), millimeter wave radar, acceleration/angular velocity sensor, data communications module (LTE), and vibrating motor.

The size and weight of the Ropot device are such that it is used mounted on the randoseru of a child in the lower grades of elementary school. In consideration of the battery capacity, the authors conducted a web-based survey on

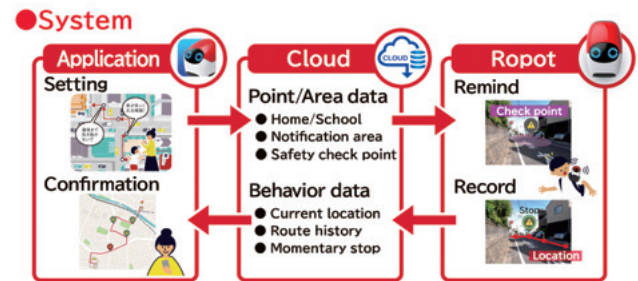
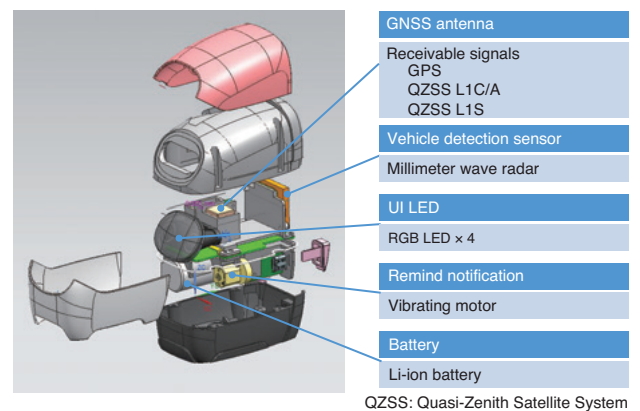


Fig. 5 System configuration



QZSS: Quasi-Zenith Satellite System

Fig. 6 Device configuration

how much time it takes for elementary school students to commute to school. The results showed that the one-way school commuting time for elementary school students throughout Japan was roughly within 50 minutes. Therefore, daily operating time was set as 100 minutes, the combined time for commuting to school and returning home. Considering that users may forget to charge the battery for a day, the authors set 210 minutes as the continuous operation time so the battery would not lose its charge over two days of commuting. The Ropot device also has an acceleration/angular velocity sensor that detects a state of repose when the device is allowed to sit still. It has a function that automatically activates sleep mode to save power at those times.

To communicate with the cloud, it uses an LTE Cat-M1, since a slow speed of a few kB/s is sufficient.

It uses a USB Type-C charge connector so the user does not have to think about which side is the front and which is the back when connecting.

The authors gave the Ropot device dust-proof/drip-proof performance equivalent to IP44 to protect against raindrops during the commute and sand and pebbles on the playground.

3.1.3. Application

An application was created that works on the Android OS (Android is a trademark of Google LLC).

The application enables the guardian to set the home, school, and check point locations. It has a graphical user interface (GUI) designed to let the guardian work with the child to raise the child's awareness of traffic safety.

Users can see the Ropot device's current location as well as check point, school, and home locations from the main screen (Fig. 7). They can use the menu (Fig. 8) to navigate to the check point result review function and notification history, which are described later.

3.2. Educational Functions

Ropot has three educational functions. This part explains the check point remind, backward check remind, and check point result review functions.

3.2.1. Check point remind

The check point remind function reminds the child to check for traffic safety at places where many vehicles are passing, such as pedestrian crossings, intersections, and parking lots (Fig. 9). In the application, the guardian registers check points in advance. Referring to the registered check point information and latitude and longitude information obtained by GNSS, the Ropot device activates the vibrating motor to remind the child to confirm traffic safety when they approach a check point. Signals that can be received by GNSS include both GPS signals and sub-meter level augmentation signals (LIS) from the Quasi-Zenith Satellite System (QZSS). This is to enable the remind function to operate more accurately at a specified

location, such as right in front of a pedestrian crossing.

The acceleration/angular velocity sensor determines whether the child stopped close to the check point. If it detects that the child did stop, the vibration notification stops and a signal is sent to the cloud indicating that the child stopped. If the child passes the check point area without stopping, however, it stops the vibration notification



Fig. 7 Application main view



Fig. 8 Application menu view

and a signal is sent to the cloud indicating that the child did not stop.

There are also situations where the child may take a different route going to school than when leaving, or the stopping locations for pedestrian crossings are different for the two trips. For that reason, the device allows the guardian to register separate check points for the commute to school and the commute from school.

3.2.2. Backward check remind

The backward check remind function reminds the child to pay attention to vehicles approaching from behind when walking on public roads (Fig. 10). When the Ropot device detects an approaching vehicle, it causes a vibration notification that encourages the child to confirm traffic safety behind them. The timing of the vibration notification takes account of the time it takes for the child to confirm traffic safety after the vibration notification occurs.

The Ropot device also uses millimeter wave radar as a vehicle detection sensor.

Using millimeter wave radar waves allows accurate detection of approaching vehicles even if the Ropot device is covered by an umbrella, scarf, parka hood, etc. Also, in general, the higher the frequency of millimeter wave radar, the smaller the antenna surface area. The frequency band of the millimeter wave radar on the Ropot device was set to 76 GHz to provide adequate approaching vehicle detection range while enabling the device to be smaller.



Fig. 9 Check point remind function

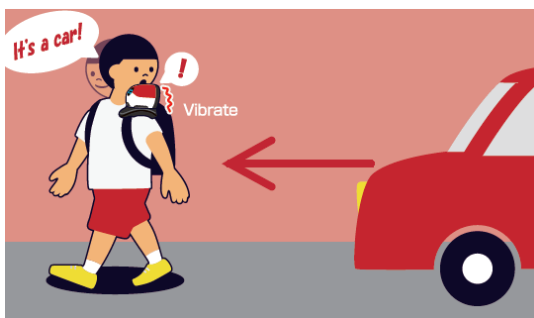


Fig. 10 Backward check remind function

3.2.3. Check point result review function

The check point result review function is intended to help the guardian and child become more aware of traffic safety while communicating with each other. Using the application, the guardian and child can view the child's location information history and a behavior history showing whether the child stopped at check points. They can see the child's actual commuting route since the location information history can show position information at 10-second intervals (Fig. 11).

Long-term changes in the child's awareness of traffic safety can be checked because the route history can show data for the past four weeks.

3.3. Receptive Functions

This part describes the receptive functions, the purpose of which is to make children, guardians, and schools comfortable with the Ropot device so it will get used.

3.3.1. Design/UX concept

When considering the Ropot device's design, the authors tried to create a form that children would feel an attachment to and would present an image of a "partner that rides on the shoulder." In addition, the following points were considered elements that children and guardians have loved for a long time.

- A size small enough to sit on the shoulder
- A form that inspires an affectionate attachment
- An expression that gives a sense of being alive

Based on the above, the design concept was defined as "Minimum & Friendly."



Fig. 11 Report view on application

The Ropot device has a rounded and warm form. It resembles a four-legged living organism. The part of the device surface that is black is used effectively to impart contrast that makes the device look even smaller.

In addition, the Ropot device has four full-color LEDs in front (upper right, upper left, lower right, and lower left) that give a sense of the device being alive. The viewer can see what state the device is in: charging, startup, or normal (Fig. 12). It also has three facial expressions: normal, smile, and sleepy. This design is intended to make the user feel more of an attachment to the device (Fig. 13).

The UX concept was defined as “the guardian working with the child to raise the child’s awareness of traffic safety.” The following elements were provided to encourage communication between guardian and child.

- Graphics that children find interesting
Ropot was designed so children themselves would find it interesting, not something that their guardians make them carry.
- GUI that makes children’s safety actions and changes in them easy to understand
The child’s safety actions and changes in them are expressed visually on the application so that the guardian can easily confirm the child’s record of stopping and give feedback to the child.
- Picture book-like user’s guide so guardian and child can read together (Fig. 14)

Pages are provided so that the guardian can show illustrations to the child to easily teach them traffic safety actions and Ropot’s functions.

The Ropot device, application, and user’s guide were designed with an integrated world view.

3.3.2. Departure/Arrival notification

Departure/arrival notifications is a function that sends push notifications to a smartphone to notify the guardian when the child has arrived at or departed from home or school.

Aside from the departure/arrival notifications, there is a function that sends push notifications to remind the user to recharge the Ropot device’s battery when it is low (Fig. 15).

To make it easier for the guardian to check the child’s location, the application shows a history of push notifications, with specific times of departure and arrival.

3.3.3. Current location confirmation

Current location confirmation is a function that forwards the Ropot device’s current location information via the cloud and displays it on the application.



Fig. 14 Traffic safety guide



Fig. 12 Status expression by LEDs



Fig. 13 Facial expression by LEDs



Fig. 15 Notification history list in application

The Ropot device uploads detected current location information to the cloud every 100 seconds, so the guardian can view the device's location within the last 100 seconds on the application. The display uses a Ropot icon to indicate the current location, and the update time is shown close by, so the user can view the Ropot device's current location and update time. Moreover, if the Ropot device's location data has not been updated for five minutes, the Ropot icon indicating current location is grayed out, so the user knows the current location is not updating (Fig. 16).

3.3.4. Silent function

The silent function keeps the Ropot device from operating inadvertently, at school for example.

Using the application, the Ropot device can be set to stop operating in places such as the school grounds where the operation of the LEDs and vibrating motor are not wanted. If the Ropot device detects that the location obtained by GNSS is at a facility where it is set to be silent, the started-up LEDs and vibrating motor will stop operating. Also, if the sensor detects continuous acceleration beyond a set level, such as a walking action, the LEDs light up and the vibrating motor operates, activating the remind function and switching the Ropot device over to normal operation. This arrangement helps prevent the LEDs from suddenly lighting up during school. Then, when walking begins, the LEDs light up so the child can see the Ropot device's operating status.

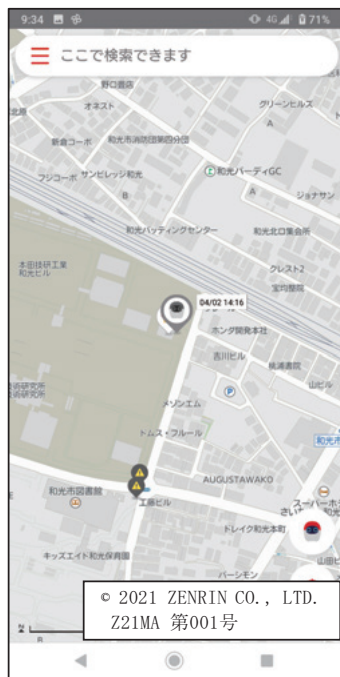


Fig. 16 Ropot current location

4. Verifying Educational Effect and Receptivity

4.1. Social Receptivity Verification: Education Expo Japan

A prototype Ropot was exhibited at the 2020 Education Expo Japan (EDIX) to verify the receptivity of school personnel to the Ropot concept and design. Visitors answered a questionnaire to evaluate the Ropot concept.

Honda set up a display booth to resemble a city intersection. School personnel who visited the booth learned that Ropot was intended to assist traffic safety education along school commuting routes and that it has a child-oriented design, functions that live up to the wishes of guardians, and a silent function so it does not become a distraction at school. The exhibit provided hands-on experience of the check point remind function and backward check remind function so school personnel could better understand Ropot (Fig. 17).

The hands-on exhibit helped school personnel to recognize that Ropot is a device intended to provide traffic safety education. It furthermore confirmed the strong possibility that school personnel would be receptive to children bringing the device to school, based on its design and the low possibility of it being a distraction at school. Overall, 97% of visitors had a favorable impression of the Ropot concept (Fig. 18).



Fig. 17 Hands-on exhibition of Ropot

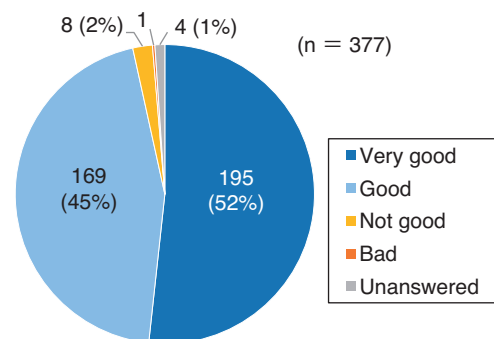


Fig. 18 Evaluation of Ropot concept

Additionally, many media outlets reported on Ropot as a device intended for traffic safety education. Some of the users participating in actual demonstration experiments at elementary schools in Wako City, Saitama Prefecture and Fukuoka City, Fukuoka Prefecture had been motivated to do so because of the media reporting. This fact confirmed that Ropot is gradually becoming widely recognized by society as a device for assisting traffic safety education.

4.2. Educational Effect and User Receptivity Testing: Demonstration Experiments

4.2.1. Experiment overview

To verify the educational effect and receptivity to the service in daily life, demonstration experiments of commuting with Ropot were conducted with families that actually had elementary school students.

The authors recruited families with children in grades 1 to 4 at two elementary schools, one in Wako City and one in Fukuoka City. Over about two weeks, 27 families participated in Fukuoka City and 25 in Wako City (Fig. 19).

4.2.2. Experimental method

Participating elementary school students used the Ropot device for 12 days while commuting to and from school. Three of them were observed for behavior while commuting to and from school. Based on questionnaires that guardians filled out before and after use and on group interviews, the authors confirmed the educational effect and user receptivity (Fig. 20). The authors confirmed school receptivity by having the principals of the two elementary schools where the experiment was conducted fill out a questionnaire on whether any trouble had occurred in the school as a result of the experiment.

Behavioral observation took place at points where traffic safety actions were considered necessary along the school commuting route (e.g. a pedestrian crossing with no signal). Observers recorded whether children actually commuting to and from school took safety check actions or not. The experiment conditions included three time periods: before wearing the Ropot device; 10 days during which the

child wore the Ropot device and the remind functions were in effect; and the final two days, when the child wore the Ropot device but the remind functions were not in effect.

Prior to conducting the experiment, the method underwent advance assessment by an bioethics committee within Honda R&D Co., Ltd. Families participated in the experiment by their own free will. The persons responsible for the experiment fully explained the purpose and content of the research and the participants' rights to the children and guardians in advance, both verbally and in writing, and received their written consent to participate.

4.2.3. Experiment results

The experiment results relating to the educational functions are discussed first. Behavioral observation confirmed that the execution of safety check actions such as stopping increased while the children were wearing the Ropot device and its remind function was in effect, as compared to the time period before wearing it (Fig. 21). Even during the final two days of the experiment, when the remind function was not in effect, the increase in execution of safety check actions as compared to the time period before wearing it was maintained (Fig. 21).

Moreover, according to a questionnaire survey of guardians one month after the completion of the experiment, 77% of guardians answered that their child's awareness of safety actions remained, even one month after use (Fig. 22).

A questionnaire survey taken immediately after the completion of the experiment asked guardians about the

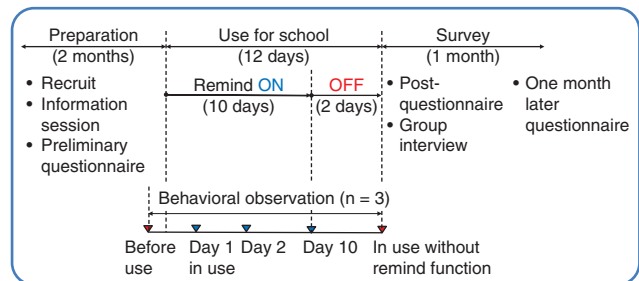


Fig. 20 Outline of experiment



Fig. 19 Demonstration experiment by elementary school students

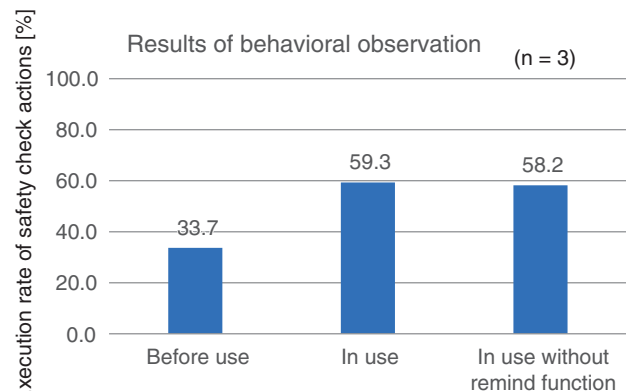


Fig. 21 Results of behavioral observation

three effects of the educational functions. It found that 80% to 90% of guardians felt those effects (Fig. 23). That same questionnaire and interviews conducted at the same time yielded specific comments with positive evaluations. Both children and guardians confirmed the effect of the functions. One person said, “I saw children stop at a pedestrian crossing where they did not previously stop.” Another said, “Feeling the vibration caused a remarkable change in awareness of what is behind (backward check).” Still another commented, “Because there was a report, I did not need to interrogate my child as I would have if I didn’t have any means to check. So we were able to talk.”

The experiment results relating to the receptive functions are discussed next. When the same questionnaire survey asked about children’s receptiveness to Ropot, 98% answered they had an attachment to it (Fig. 24). Specific comments heard during group interviews immediately after the experiment was completed included “My son was even more enthusiastic than us, his parents, and he kept saying he wanted to wear it. It really seemed like a partner for him.” Another said, “My child loved it so much, petting it and talking to it.” Another: “My child really seemed to like how the Ropot device’s eyes changed.” Still another: “Starting about the third day, it became a habit to wear it. My child just put it on without being told to do so.” Comments like these confirmed that the children were largely receptive to the partner design and “Minimum & Friendly” concept.

The questionnaire survey taken immediately after the completion of the experiment asked about the guardians’ receptivity. It found that 70% to 80% of guardians felt the effect of the receptive functions “departure/arrival

notifications” and “current location confirmation,” indicating a high level of receptivity among guardians as well (Fig. 25).

Concerning schools’ receptivity, results of the questionnaire for principals of the two elementary schools where the experiment was conducted indicated no reports of trouble at either school. There were no cases where bringing the Ropot device into school caused any disruption there.

To assess guardians’ evaluation of the service overall in light of these educational functions and receptive functions, a questionnaire survey taken one month after the completion of the experiment asked about guardians’ inclination to have their children use Ropot in future. It found that 92% said they would like to do so (Fig. 26). They were also asked about what type of usage scenario they would like to see. Many indicated they would like to have their children use Ropot on outings other than commuting to and from school. For example, one said, “It would be nice if there were some kind of platform that would allow Ropot to sit somewhere besides on a randoseru, like on a backpack or the shoulder strap of a bag.” Another commented, “It would be great if a child could use it not just when commuting to and from school, but also on their days off or when going to lessons.”

4.2.4. Discussion

In terms of the educational functions, the fact that the increase in actions to confirm traffic safety and the awareness of traffic safety remained even after the experiment was completed indicates that there is an

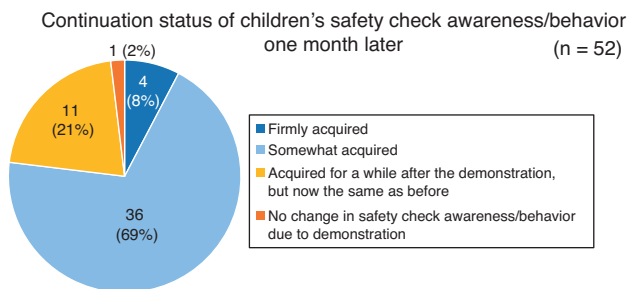


Fig. 22 Continuation of child safety confirmation awareness one month later

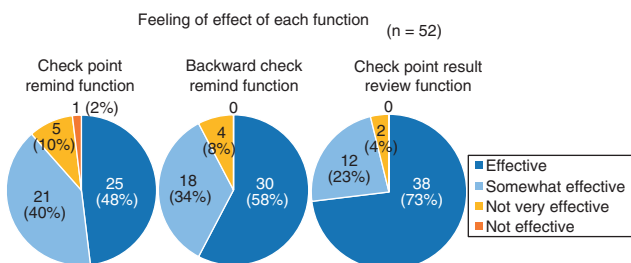


Fig. 23 Feeling of effect of each educational function

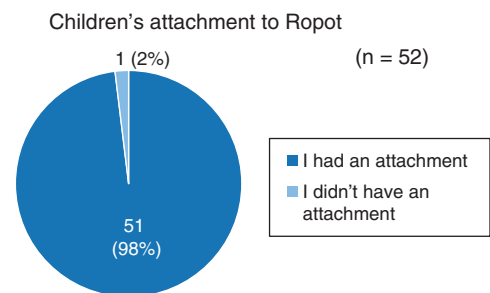


Fig. 24 Feeling of attachment

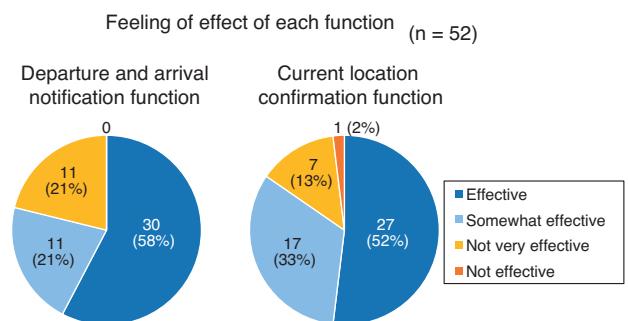


Fig. 25 Feeling of effect of each function to increase receptivity

educational effect. Moreover, the fact that there was a strong feeling of the effectiveness of these functions indicates that the positioning function provided by GNSS and the vehicle detection function provided by millimeter wave radar offered sufficient performance.

Concerning the receptive functions, the fact that both children and guardians evaluated Ropot so highly indicates that both children and guardians would be receptive to it as a product. On the other hand, the fact that so many guardians commented that they would be inclined to have their children use Ropot in situations other than commuting to and from school indicates a need for technical development to enable usage in a wider range of life settings in future.

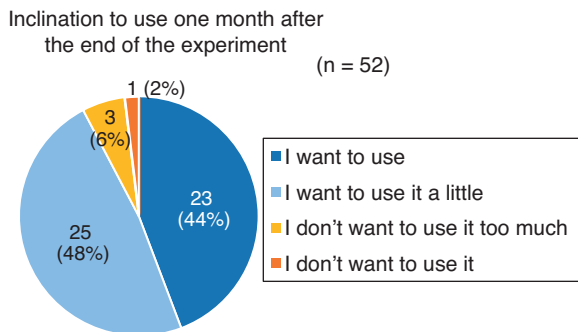


Fig. 26 Inclination to use after experiment

5. Conclusion

The authors developed a traffic safety advice robot to assist the teaching of traffic safety to children in the lower grades of elementary school.

They determined the educational functions that Ropot would need based on children's capabilities and characteristics and from the point of view of traffic safety education, and determined the receptive functions it would need based on interviews.

To achieve the educational functions, the robot requires high-precision positioning and the ability to detect objects behind the child. The robot was developed using GNSS to provide positioning precision and millimeter wave radar for the capability of detecting objects behind the child. To achieve the receptive functions, a partner design and silent function were adopted and a size and weight were chosen that would not burden the child.

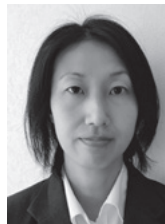
The educational trade fair and demonstration experiments showed that schools, children, and guardians are actually receptive to Ropot. This and the fact that increases in safety actions were observed after just 12 days of wearing Ropot confirmed the effectiveness of its educational functions and receptive functions.

The aim going forward is to consider expanding the range of Ropot's usage and contribute broadly to traffic safety education.

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