



A Study on HCI of a Collaborated Nurture Game for Sleep Education with Child and Parent

Madoka Takahara¹(✉) and Shun Hattori²

¹ Ryukoku University, 1-5 Yokotani, Seta Oe-cho, Otsu 5202194, Shiga, Japan
takahara@rins.ryukoku.ac.jp

² The University of Shiga Prefecture, 2500 Hassaka-cho, Hikone-City 5228533, Shiga, Japan
hattori.s@e.usp.ac.jp

Abstract. Japan is now called to be a “sleep debt nation,” and this has long been a social problem. In recent years, sleep disorders in children have also been on the rise. To address these problems, it is important to provide sleep education not only to adults but also to children, and to enable children to enjoy managing their own sleep. In this paper, this paper proposes a game in which parents and children cooperate to raise cats by sleeping well and using the food that is given as a result.

Keywords: Sleep Education · Collaborated Nurture Game · Sleep Trouble · Sleep Debt · Parent and Child

1 Introduction

Japan is now called to be a “sleep debt nation [1–3]” or a “sleep deprived nation [4]” and has long-solved social problems about sleep, with major economic losses being pointed out. Furthermore, in recent years, sleep disorders in children have also been gradually increasing and are considered a serious problem [5–7]. To solve these problems, it is important to provide sleep education not only to adults (parents) and university students, but also to children, and to enable children themselves to enjoy managing their sleep [8–11].

Tamura et al. [9] studied the effects of sleep education in a classroom format and the practice of target behaviors for one month on sleep and daytime conditions and suggested that ‘sleep classes are effective in ensuring sleep, irritability, and improving daytime sleepiness in early and middle elementary school students.

In addition, by Furuya et al. [11], ‘As a result of a single sleep education lecture, in non-attending schools (to parents only) they had more regular waking times after the lecture. In the schools that attended both children and parents, they showed more regular waking and sleeping times after the lecture, and the percentage of correct answers increased in sleep knowledge.

These results confirm that the students of schools that attended the lecture were more likely than the students of non-attending schools to improve their regularity of waking and going to bed and to disseminate correct knowledge.

However, sleep education for children has not yet been developed. However, sleep education for children is still in its infancy.

According to a survey of the literature on "sleep education" by Ohso [12], "If sleep education programs in Japan are mainly aimed at improving sleep knowledge, large cross-sectional studies are considered sufficient and have already been reported to be successful. On the other hand, there is a lack of empirical evidence showing that certain methods are superior to others in changing sleep behavior, and further study is needed regarding the number and duration of effective interventions." and "ICT technology may automatically integrate both visual and textual information, which may lead to effective learning in children who are proficient in both visual and textual learning.

It is pointed out that in sleep education for children, whether in the form of a class or a one-shot lecture, the learning is passive, and it is not yet certain whether the children's own sleep behavior will change or continue afterwards.

To continuously improve the sleep behavior of children as well as adults (parents), a proactive learning system utilizing ICT technology based on a theory that promotes behavioral change, rather than the conventional passive learning, is considered necessary.

Therefore, this paper proposes a game (web application) in which parents and children cooperate to raise a cat by sleeping well and using food given because of daily sleep data input, for both parents and children to learn sleep education proactively and continue to change their sleep behavior.

Thereafter, Sect. 2 discusses the requirements of the proposed system of sleep education for parents and children. A survey study of existing sleep (educational) games also be conducted and compared with the proposed game. Then, Sect. 3 describes the design of a cooperative training game of sleep education for parents and children, "Neko × Neko: Children who sleeps with a cat grows up well," and shows some demonstration screens. Finally, Sect. 4 summarizes.

Although the system is currently only developed at the demonstration level, the system will be developed as a prototype system and will be conducted demonstration tests with parents-children subjects at kindergartens and other locations.

The differences between single-player play, in which only parents and children play together, and cooperative play, in which parents and children play together, in which play is basically only at bedtime or upon waking, and in which play is always on-demand, including these times, and in which players' preferences and interests, such as dogs or flowers as well as cats as characters to be trained, may affect the sleep deviation [13], the effects of sleep education, and whether there are significant differences in the persistence of changes in sleep behavior.

2 Consideration of Requirements for the Proposed System

This chapter examines the requirements of the proposed game after surveying existing sleep (education) games and research, focusing on how to realize this "initiative" and "continuity" to have both parents and children proactively learn sleep education and continue to change their sleep behavior. This chapter focuses on the following three points as points to realize "independence" and "continuity" in sleep (educational) games.

- On-demand at all times, not only at bedtime or waking triggers

- Cooperative play, not just single player.
- End content, not just (multi-)endings

2.1 System Design Policy

The purpose of this study is to encourage parents and children to learn sleep education together proactively and continue to change their sleep behavior. To realize this objective, a system called "Neko × Neko: Children who sleep with cats grow up well", a cooperative training game for sleep education for parents and children, is proposed and designed in Sect. 3.

- **Why a game about sleep (education)?**

Because it is important for parents and children, especially children themselves, to be able to manage their sleep in a "fun" way, this research utilizes "gamification". Rather than a sleep "education (class)" from parents, children themselves start the sleep (education) game on their own initiative on a continuous basis, input sleep data, understand it positively, learn how to sleep better, and improve their sleep.

- **Why nurturing games?**

There are a wide variety of game genres, but in order for parents and children to be able to manage their sleep as "happily" as possible, a genre that eliminates elements that may cause negative emotions and can be controlled to positive feedback is better [14]. In addition, children (potentially) grow up well through good sleep, which naturally be reflected in the characters (cats) in the game and be easily understood as positive feedback, so we adopt "nurturing games" as a genre. The genre of "RPG (Role Playing Game)" can also be linked to children's growth, but it requires understanding of various roles and is too complicated and is not suitable for small children. Since universal design including small children as target players is also important, simplicity (and fun) of the game is also important.

- **Why a cat training game?**

Although "sheep" characters are often used in sleeping games, one of the origins of "cat" is "neko" (a child who sleeps well), and this game character is appropriate for the purpose of this study. Also, if you take a ranking of animals' people would like to have as pets, dogs and cats are so universally popular, at least in Japan, that they always compete for first place. According to the National Dog and Cat Breeding Survey [15] conducted annually by the Pet Food Association of Japan, dog ownership continues to decline, while cat ownership reversed in 2017 and has been on a gradual upward trend since then. On the other hand, abandoned cats in particular and the killing of cats have become a social problem [16], which this research decided to incorporate into the storyline of the proposed game.

2.2 Policy System Design Policy

While there are not a few existing studies [17, 18] on "gaming disorder and sleep," few existing studies [19–21] on "Sleep (Educational) Games." Sudo [18] found that "the impact of game time on sleep duration and grades is slight but not large for elementary and middle school students, and has no clear effect on high school students." He analyzed the results of the study. Also, Wander [20] is an audio game that encourages reduced

smartphone use and provides breathing exercises to improve sleep quality near bedtime based on gamification theory. Pro Sleeper [21], on the other hand, is a mobile audio game that can be played with eyes closed, utilizing meditation and autonomous sensory climax response (ASMR) to improve players' sleep quality. However, unlike the proposed sleep education game, it is not intended for parents and children and has only single-player play.

The iOS/Android application "Sleep x Game [22]" is a game in which when the player goes to bed, the sheep go on a journey to the "end of the night" and the gentle sleep music of nature, such as rain and waves, helps the player fall asleep. The game also claims that "as players enjoy the game, they will continue to develop good sleeping habits. Daily sleeping hours are automatically recorded, and various sheep (cat food in our sleep education game) are awarded accordingly to grow the flock. Furthermore, players can also receive sheep for meeting unspecified other players and can encourage other players to improve their sleep by pressing the "Good Sleep Button," thereby encouraging everyone to continue the game. The game has many similarities to our proposed sleep education game but differs in that it is a more closely cooperative nurturing game that focuses on the proactive sleep education of specific parents and their children.

In addition, it is beginning to be said that "Pokémon Sleep," which was announced by the Pokémon Company at the Pokémon Business Strategy Presentation in May 2019 and is targeted for distribution and release in 2020, may soon be on the way. Pokémon Sleep is a smartphone application that is linked to Pokémon GO Plus+, a palm-sized device with a built-in accelerometer that can measure sleep time when placed under the user's pillow during sleep, and has the concept of "making getting up in the morning a pleasure" and "making sleep and waking hours an entertainment experience. The application is a smartphone application with the concept of "making people look forward to getting up in the morning" and "making sleeping and waking hours entertaining. However, there was no further news on Pokémon Presents [23] on August 3, 2022. As soon as more details become available, it is needed to compare the similarities and differences with our proposed sleep education game.

Several other games have also been proposed that are not based on the player's sleep, but are based on one of the player's own actions: walking (number of steps). Among them is the wearable "Tamagotchi Smart," an evolution of the "Tamagotchi" series of keychain-type electronic games from Bandai, in which the number of steps taken by the player is counted and the reactions of the "Tamagotchi" creature to be trained changes. Similar wearable electronic games with pedometer functions include Hudson's "Tekketsu Angel," Nintendo's "Pocket Pikachu," and the Pokémon pedometer "Pokéwalker," but there are no cooperative games to be found. Location-based "RPGs" rather than simple "training games" include "Pokémon GO" and "Dragon Quest Walk".

2.3 Sample On-Demand at Bedtime or upon Waking vs. Always On-Demand

Existing sleep (educational) games, including the application "Sleep × Game [22]," are often simply triggered at bedtime or upon waking up to play the game. Although it is not necessarily a bad thing in the beginning to make it a routine task to keep track of and check sleep data every day, it may become a mere task and easily lead to boredom as a game. The application "Sleep × Game [22]" allows users to set their daily bedtime and

wake-up time, but if they receive a notification just before these times, they may feel forced to sleep regularly. This is not an improvement in proactive sleep behavior in the least.

Therefore, we believe that the sleep education game this research proposes should not only be triggered at sleep-related times such as bedtime or waking time, but also should have a mechanism that allows players to play the game at any time they like and enjoy it in some way. For example, the following functions are being considered.

Players can feed the cat at any time they like.

(The cat's food is newly given when sleep data is input after waking up, but feeding the cat is on-demand).

The player can communicate with the cat at any time (click (touch) on the cat and it will purr or respond to the player's interaction).

2.4 Single Play vs. Cooperative Play

Existing sleep (educational) games are often just single-player games, with no awareness of other players. Only the application "Sleep × Game" [22], which was the only one in our survey, has some kind of interaction with other players, such as pressing the "Good Sleep Button" to encourage other players to improve their sleep, but it is an unspecified other player, and even if they press it casually in a workmanlike manner, there is no sense that they are connected to each other or to the game as friends. However, it is unclear whether this will lead to initiative and continuity, since the players are unspecified other players, and although they may push the button in a casual, workmanlike manner, they do not feel that they are playing together as friends to improve sleep.

Therefore, we believe that the sleep education game this paper proposes requires a mechanism for closer cooperative play between parents and children, who are mutually identified as other players. It is hoped that this will create a sense of working together as friends to improve sleep, which will lead to positive encouragement and continuity with each other. For example, the following functions are being considered.

The system can tell whether or not a pair of players have already entered their sleep data.

When both players input sleep data, additional cat food will be given to the cat, and if both sleep well, an additional bonus will be given.

2.5 (Multi)endings vs. End Content

As a cat training game based on the player's daily sleep data input, a story and an initial easy-to-understand goal are necessary, and therefore, a single ending when a weakened cat becomes healthy and a multiple ending depending on the difference in the process of becoming healthy are prepared. However, there is a concern that this may cause problems with continuity afterwards. It is considered adding endless content that will not bore the player, such as making the character's dialogue responses smarter in response to further feedings.

3 Design of the Proposed Game

3.1 Overview (Game Flow)

The general flow of the proposed game is as follows.

Step 0 The system administrator gives each player (parent-child pair) an ID/PW as login information.

Step 1 Each player logs in initially. The story of protecting a weak cat, fostering it, and recovering it, as well as the sleeping (play) method as shown in Fig. 1, are explained to the players.

Step 2. Each day, each player enters his/her own sleep data, based on which the cat is given food. The parent and child work together to feed the cat at any time during the day, with the goal of the cat's full recovery. The special bait will not be given unless the pair of players also input sleep data, so they must communicate with each other to encourage sleep data input. The history of each player's sleep data can be viewed on the application, but the sleep data of the paired player cannot be viewed, so if necessary, the players communicate with each other about sleep and ask each other to view the data. Even without feeding, clicking (touching) the cat will elicit a reaction from the cat, and the cat will also take action without the player having to do anything. In the demo version, it is random.

Step 3: Once the cat is fully recovered, the ending is reached. We collected as many action logs of the players (parent-child pairs) on the application as possible, and changed the ending depending on the differences in the process.

Step 4: Even after the ending, the sleep management of each player (parent-child pair) will continue endlessly, and endless contents will be added to keep the players (parent-child pairs) occupied, such as making the cat AI's interactive responses smarter in response to further feedings. On the other hand, if the cat cannot continue to get a good night's sleep, it will become weak again.

戻る

寝 (遊び) 方

おやこで まいにち ぐっすり 寝ようね
 親子で 毎日 ぐっすり 寝ようね
 きそくただしく 11 時間は 寝てね
 おとうさん あかあさん 6 時間は 寝てね
 お父さん お母さん 6 時間は 寝てね
 おいしい えさを こねこに いっぱい あげてね
 美味しい えさを 子猫に いっぱい あげてね

Fig. 1. How to sleep (play) “Cat × Cat.

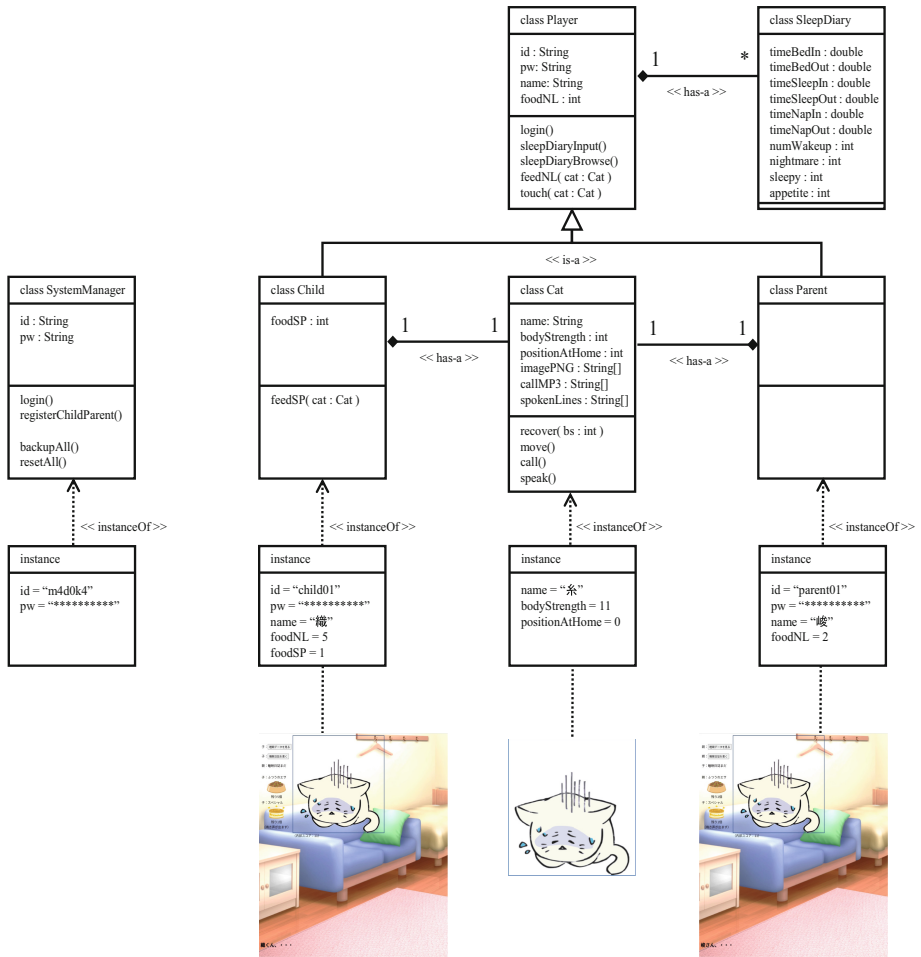


Fig. 2. Class diagram, instances and demo screens of “Cat × Cat”, a cooperative training game for sleep education for parents and children.

3.2 Data Management

The actors in the proposed game are the players (parent-child pairs) and the system administrator, and one of the entities is the cat character that the players (parent-child pairs) share and cooperatively develop. As shown in Fig. 2, these four are the basic classes.

Information Security

Since daily sleep data is extremely sensitive personal information, and since it is planned to incorporate not only sleep data but also daytime activity data to evaluate sleep quality in the future, information security must be strictly enforced. However, the demo version in

this paper uses only simple basic authentication with an ID/PW, which is still problematic and needs to be improved.

Cat Feeding Based on Sleep Data Input

First, as shown in Fig. 3, players (parents and children) input their daily sleep data. Fitbit sense and other sleep sensors can be used to facilitate sleep data input, but we have chosen to input the data manually in order to make the players more aware of their own sleep data. However, it will be necessary to explore more convenient interfaces in the future. In the demo version of this paper, the following questions were asked, but it will be necessary to consider the selection of questions in the future.

- Q1. Time of going to bed and time of waking up (required).
- Q2. Time of falling asleep and time of awakening (required).
- Q3. Nap start time and nap end time (optional).
- Q4. How many times did you wake up during the night? (required) Q5.
- Q5. Did you have scary dreams? (required) Q6.
- Q6. When you woke up, did you still want to sleep? (Required) Q7.
- Q7. When you woke up, did you have an appetite? (Required) Q7.

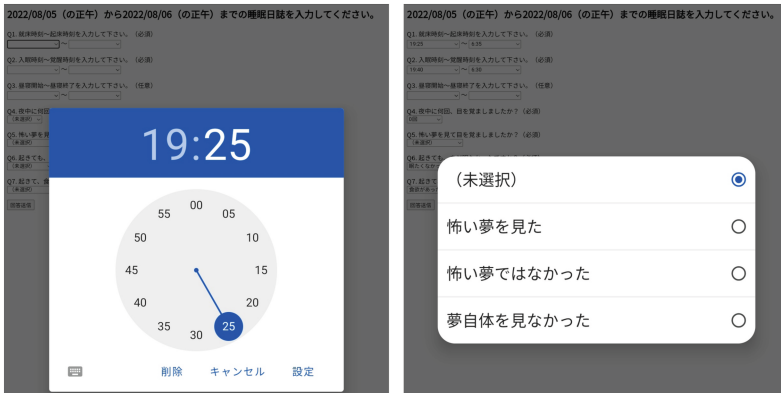


Fig. 3. Daily sleep data entry (bedtime and dreaming).

Next, based on the player’s daily sleep data input, the cat is given food as shown in Fig. 4. However, in the demo version of this paper only used the following times.

$$\text{Sleep duration [h]} = \text{Wake time} - \text{Sleep onset time.}$$

In the future, it is consider estimating not only the quantity (time) of sleep, but also the quality of sleep based on other questionnaire items, and taking this into consideration when assigning cat food.

First, the “normal feed” is calculated independently based on the daily sleep data input for each parent and child, is independently given, and can be independently fed to the cat. The “special bait” is given to the parent-offspring pair at the time when both parent-offspring pairs have made their daily sleep data inputs, and only the child can feed the cat. The number of “specials” is calculated by the following equation.

$$\text{Usual number of feeds [pcs]} = \lfloor \min (“\text{sleep time}” - “\text{MIN}”, 0) / \text{UNIT} \rfloor.$$

2022/08/05 (の正午) から2022/08/06 (の正午) までの睡眠日誌を入力してください。

Q1. 就床時刻～起床時刻を入力して下さい。(必須)
 19:25 ~ 6:35

Q2. 入眠時刻～覚醒時刻を入力して下さい。(必須)
 19:40 ~ 6:30

Q3. 睡眠開始～睡眠終了を入力して下さい。(任意)
 ~ ~


Q4. 夜中に何回、目を覚ましたか？(必須)
 0回

Q5. 怖い夢を見て目を覚ましたか？(必須)
 怖い夢ではなかった

Q6. 起きてても、まだ眠たかったですか？(必須)
 眠たくなかった

Q7. 起きて、食欲がありましたか？(必須)
 食欲があった

回答送信



以下のエサをゲット！
 ふつうのエサ：3個
 スペシャル：0個

Fig. 4. Feeding cats to children based on sleeping hours.

However, UNIT is a unit of time common to parent and child, and is 1.5 [h] in the demonstration version of this paper; changing it to 1.0 [h], for example, will make it easier to be assigned. In addition, MIN is a parameter for each parent and child, and is the minimum time that they should sleep. In the demonstration version of this paper, the MIN for the child is set to 5.0 [h] and the MIN for the parent to 3.0 [h]. Since this is only a provisional version, it is considered more appropriate settings in the future by referring to existing studies. Note that $\lfloor \cdot \rfloor$ is the floor function. As a general rule of thumb, the number of feeds to be given is 4 daily when the child sleeps 11.0–12.49 [h], which is the target recommended time [24], and one feed can increase the cat's fitness by +1, so the cat's fitness (internal score) is designed to recover to 100 or more in about 25 days in single-player play.

On the other hand, the number of special baits is determined by the following formula.

$$\text{Special (bites)[pcs]} = \lfloor \text{Sleep Time}_{\text{Child}} / \text{RCM}_{\text{Child}} \rfloor \cdot \lfloor \text{Sleep Time}_{\text{Parent}} / \text{RCM}_{\text{Parent}} \rfloor$$

However, RCM is a parameter for each parent and child, and is the target recommended sleep time. In the demonstration version of this paper, the RCM for the child is set to 11.0 [h] and the RCM for the parent to 6.0 [h]. In fact, it is desirable to set the RCM of the parents at about 7.5 [h], but many parents are not realistic, and it is easy for the parents to prevent specials from being awarded at all, so this research has tentatively lowered the target a little. Therefore, it has tentatively lowered the target a little. In this case, it would be better for sleep education to clearly state this as the next target, rather than implicitly changing it internally. If the current target seems difficult to achieve, a mechanism may be necessary to lower the target RCM value a little more, depending on the status of the granting of specials. The guideline for granting specials is at most one each day. If the parent gets more than 12.0 [h] of sleep, more than two is possible,

but it is not realistic for the child to get more than 22.0 [h] of sleep, so it depends on the parent's sleep.

Cat Changes Based on Feeding

Based on the daily sleep data input by the player (parent and child), the cat is given food, which the player can freely feed to the cat. The cat changes depending on the feeding of "normal food" and "special food" as follows.

The cats can be fed independently by clicking (touching) on the "normal feed" icon, which increases the cat's strength (internal score) by +1. As shown in Fig. 5, the cat's feeding is indicated in an easy-to-understand manner, and the cat will purr with sound and dialogue, making you happy.

Special: When the icon is clicked (touched), only the child can feed and the cat's strength (internal score) is increased by +3, although this is granted to the parent-child pair. As in Fig. 4, the cat's having been fed is displayed in a way that is easy to understand, and the cat is more pleased than with "normal food" with a happier sound and dialogue.

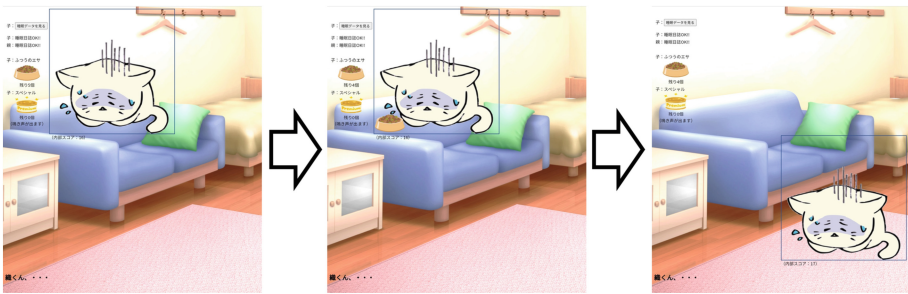


Fig.5. Changes in cats due to feeding of "normal food."

In addition, to positively reflect the player's daily good sleep to the cat, the character to be trained, the cat's appearance (image) is monotonically changed according to the cat's physical strength (internal score), as shown in Fig. 6. Also, the cat's lines during normal times when the main screen is simply displayed and during feeding events are also changed. The cat's physical strength is designed to monotonically increase until it is fully recovered once, but then it is also equipped with a mechanism that allows it to weaken again if it is left too long.

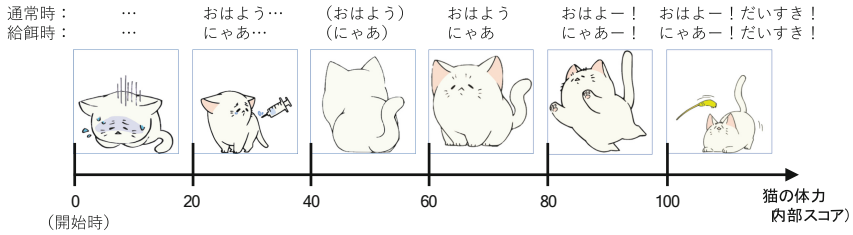


Fig. 6. Appearance and lines change according to the cat's fitness.

4 Conclusion

This paper proposes “Neko x Neko: Kids who Sleep with Cats Grow Up Well,” a cooperative cat-raising game (web application) in which parents and children cooperate to raise cats by using bait given as a result of daily sleep data input, so that both parents and children can learn sleep education proactively and continue changing their sleep behavior. The design proposal and some demo screens were also shown. It is planned to develop a prototype system and conduct demonstration tests with parents and children at kindergartens. This research also considers the following functional enhancements.

4.1 Diversity of Parent-Child Pairings

In the demo version of this paper, child IDs are paired one-to-one with parent IDs. It is also considered at least one-to-two pairings between children and their parents, as well as support for a wide variety of family structures, such as parents and siblings, grandparents, and so on. However, since the game balance, such as the quality and quantity of bait grants and the amount of cats' recovery by such bait, is adjusted assuming one-on-one pairing of parents and children, it is necessary to reconsider this issue when increasing the number of players in the grouping.

4.2 Visualization of Sleep Data History

In the demo version of this paper, only a list of numerical data is shown, but in addition to existing visualization methods such as bar graphs and line graphs, this research will also explore new visualization methods that are only possible with parent-child pairs. Although the parent-child pairs are only shown whether or not they have already entered their sleep data for the day, it is expected them to be aware of each other's sleep data entry and to interact with each other in a realistic manner to encourage sleep data entry.

4.3 Interactive Response AI for Cat Characters

This research considers a dialogue response with the cat character as one of the end (less) contents after the cat has fully recovered and once the ending has been reached. Research to give the dialogue response AI a personality [25], for example, will be utilized. A proposal to increase the size of the dialogue response database of the dialogue response

AI of the cat character and make it smarter as the cat's physical strength increases could be considered, but if it is simply linear, there is a fear that the improvement in smartness will gradually become imperceptible, so exponential might be better. On the other hand, it is difficult to keep increasing the size of the dialogue response database exponentially, which is a vexing problem. Therefore, also it is considered the idea of not only controlling the size of the dialogue response database but also combining it with a forgetting curve and updating it with more recent (topic) dialogue response data. In addition, this research will increase communication with the cat character, for example, by personalizing (personalizing) the cat based on machine learning of the player's interests and preferences based on the content of the dialogue responses, or, conversely, by forgetting to feed or talk to the cat if the player neglects to do so.

Acknowledgement. This work was supported by JSPS KAKENHI Grant Number 20K13787.

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