

# Petting Pen for Stress Awareness and Management in Children

We found that children in elementary school often experience stress during task performance. Limited coping skills and lack of stress awareness restrict children's ability to manage their stress. Many designs and studies have proposed different stress detection and intervention solutions. Still, they often overlook the potential of enhancing everyday objects and actively sensing stress-related behavioural data during human-product interaction. Therefore, we propose Petting pen as an interactive robotic object for children to manage their stress during task performance. It detects, validates stress, and further intervenes in stress during a process of natural writing and relaxation interactions. The design is an iteration based on our previous research results of a stress-aware pen, enhanced with tactile needs, robotic interaction, and integration of behavioural and bio sensing capabilities. Petting pen is supposed to bridge the gap between robots and everyday objects in mental health applications for children.

## INTRODUCTION

Stress from study and heavy workload has significantly contributed to mental health problems in children from East Asian countries such as China, Japan and Korea(Sun et al., n.d.; Tan & Yates, 2011). The pressures associated with homework and tasks are one of the primary sources of stress in elementary school children from these countries. Excessive and long-term stress from studying may lead to severe psychological problems such as depression, anxiety and even suicidal thoughts(Long et al., 2022). Unlike adults, who are more capable of being aware of self-stress states, children, especially at the elementary school level, cannot recognise and cope with the day-to-day stress that confronts them during study and task performance(Ireh, 1994). Research shows that most children do not receive support or treatment for mental health difficulties(Kassymova et al., 2018). Due to the vulnerability of children in stressful situations, it is essential to consider alternative ways and methods during the studying process for promoting mental well-being.

Real-time stress detection and intervention



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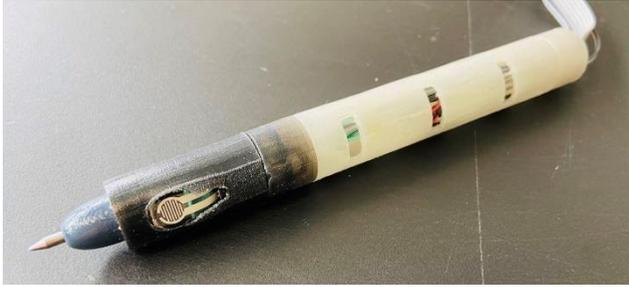
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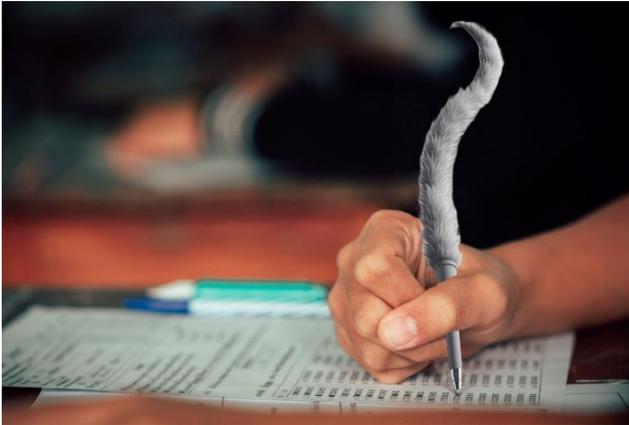
technologies play an essential role in monitoring and improving mental health in children(Boruah & Pathak, 2021). Many smart wearable devices(Welch et al., 2022) have been developed to monitor children's mental health through physiological data. These devices often do not embody the potential of behaviour change. And most of the devices provide limited contextual information and overlook stress-related behavioural data.

Our previous work(Li et al., 2022) has shown the potential relationship between stress and handwriting behaviours in children during task performance. These stress-related behaviours can be captured during human-product interactions in children's daily life. Thus, to help young children manage their stress during study and task performance unobtrusively, we propose using an everyday object already used in children's daily life but enhanced with robotic technologies.

We explored which types of interactions with everyday objects were potential stress indicators for elementary school children in the context of studying and task performance at home. Petting pen is therefore designed for monitoring stress and providing relaxing interaction with children. It detects and responds to stress-related



**Figure 1. First prototype - Apen**



**Figure 2. Petting pen overview**



**Figure 3. Curving tail in stress**

behaviours and physiological signals of children. As an everyday robotic object, Petting pen helps children be aware of their stress states through tangible interaction.

Yet, Petting pen is still a conceptual design which was iterated based on the design and research results of Apen(Li et al., 2022), which has been prototyped and tested in children. We enhanced Petting pen with robotic or animal-like behaviours to indicate stress states and interact with children during task performance at home.

### **DESIGN PROCESS**

Petting pen as the design iteration based on the user testing results of Apen(Li et al., 2022) focuses on improving the user interaction with the pen. A pen as an everyday object was identified that associated with stress-related behaviours of children during studying and task performance through interviews and observations. We made the first prototype, named Apen (Figure 1), which embedded pressure sensors, LED lights and vibration motors for the interaction. We tested Apen with four neurotypical children while performing their tasks. The results revealed that 1) There is an apparent correlation between physiological stress, perceived stress and writing behaviours from the collected data. 2) Lights and vibration as stress indications did not significantly increase the awareness of stress in children or change children's behaviours. 3) The means of interaction are limited and hard to be understood by children.

In order to further develop the pen, we first conducted user interviews and user questionnaires with 92 children in elementary school. We found that most children have a limited understanding of what stress is. They tend to associate stress with destructive emotion, low morale and alertness.

However, most children are interested in seeing the indication or concretisation of their stress states during studying. Moreover, the most popular intervention in children to deal with high-stress situations during task performance is taking a break and interacting socially with friends, parents or pets. Taking the findings into design consideration, the iteration should offer concrete stress indications that link to children's interpretation of stress. And the iteration should also provide a chance for children to relax or take a break while sensing the high-stress signals. Following it, we transferred findings in a brainstorm session to generate more detailed design in the form of a pen. We converged design solutions by the evaluation of the level of interaction and automation, the usability, and the acceptance of children.

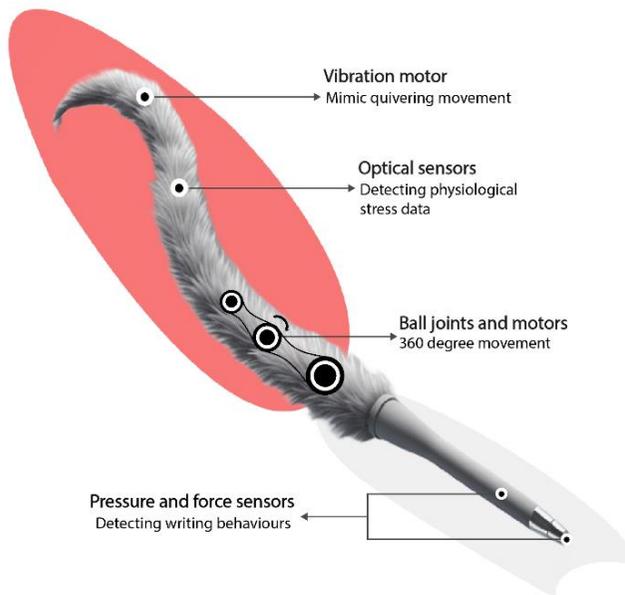
### **FINAL DESIGN**

*Design overview.* Petting pen(Figure 2 shows) is designed for children to aid stress management during studying and task performance. It detects children's stress-related writing behaviours and physiological data and provides animal-like reactions as feedback. In this way, it aims to increase the stress awareness of children and intervene with stress with relaxing interaction. As an interactive robotic object, Petting pen is enhanced from an everyday object of children in the context of task performance. We enabled Petting pen with a biomimetic interface to engage children's interaction besides general writing purposes. With the consideration of tactile needs and other relaxation strategies in stress intervention of children, we then finalised the design of Petting pen for stress management in children.

*Working principle.* Petting pen is able to detect handwriting and hand-holding behaviours when it is in use. Machine learning system supports analysing and classifying stress-related behavioural data. When the potential stress behaviours are detected, the main body (tail-looking) of the pen start curving



**Figure 5. Different reactions on physiological data**



**Figure 7. Sensors and actuators in Petting pen**

(Figure 3 shows). The higher and longer stress-related behaviours are detected, the more deformation the tail becomes. The pen is not able to be used when the tail is entirely lumpy. To return the normal shape, the pen has to rest or react to the physiological data detected through the tail part. The tail sways gently (Figure 5 left side shows) if no physiological stress signal is detected, whereas the tail is puffed up and twitching (Figure 5 right side shows) to alert the user.

*Interactive experience.* Figure 6 visualises the main interactive stress management process between children and Petting pen. When children use the pen without stress, Petting pen has a waving tail occasionally as a relaxing behaviour. While children keep studying and feeling stressed, they express stress on the writing and hand-holding pressure. Petting pen captures these stressful behaviours and starts curving and becoming lumpy. Children may or may not notice the deformation of the pen, but they can no longer use the pen to write at some point since the deformation. At this moment, Children have to take a small break from their studying to pet their pen. The pen shows the hooked tail as an unsure behaviour regarding children's mental state. The hooked tail guides children to pet and touch it while detecting their physiological data and validating if they are in a high-stress state. When the tail starts swaying or flicking softly, it indicates no physiological stress detected, and children can continue working with Petting pen. If there is prominent physiological stress input, the tail will puff up or straight up and quiver at the tip. In this way, children sense the tactile feedback as a stress alert and can further intervene in their stress by taking an extended break or other activities. In the high-stress state, Petting pen behaves challenging to be used with the purpose of providing a distraction or an unplanned break for children during their task performance.

*Technical details.* Figure 7 explains the embedment of the sensors and actuators in the pen. Petting pen is embedded with pressure and force sensors in the front body and the point where it detects hand-holding pressure and writing pressure. Our previous study (Li et al., 2022) had preliminary results that revealed the correlation between hand-holding, writing pressure and stress level. With the machine learning (ML) technique, Petting pen can have a personalised stress behaviour model that captures the stress-related writing behaviour data for each different individual. There are optical sensors on the main body of the pen that detect contact and stress-related physiological data. According to data and the analysed stress state, actuators, including connection joints, motors will collaborate and react differently.

## CONCLUSION

Petting pen is an enhanced everyday robotic object supporting children in managing their stress during study and task performance. Based on the natural interaction of an everyday object in children's studying environment, we enhanced a pen with animal-like robotic behaviour. It is enabled to detect stress-related writing behaviours and physiological stress data during the interaction. The design needs to be further prototyped and validated in the field study regarding the usability and the effectiveness of improving stress awareness and relaxation. We also expect several iterations in the further design process to enhance the design of petting pen. Furthermore, a personalised ML model is also needed to be developed for studying an individual's stress-related writing behaviours. We aim to connect Petting pen with other smart devices as a system of Internet of Things for supporting children's mental health in different contexts of everyday life.

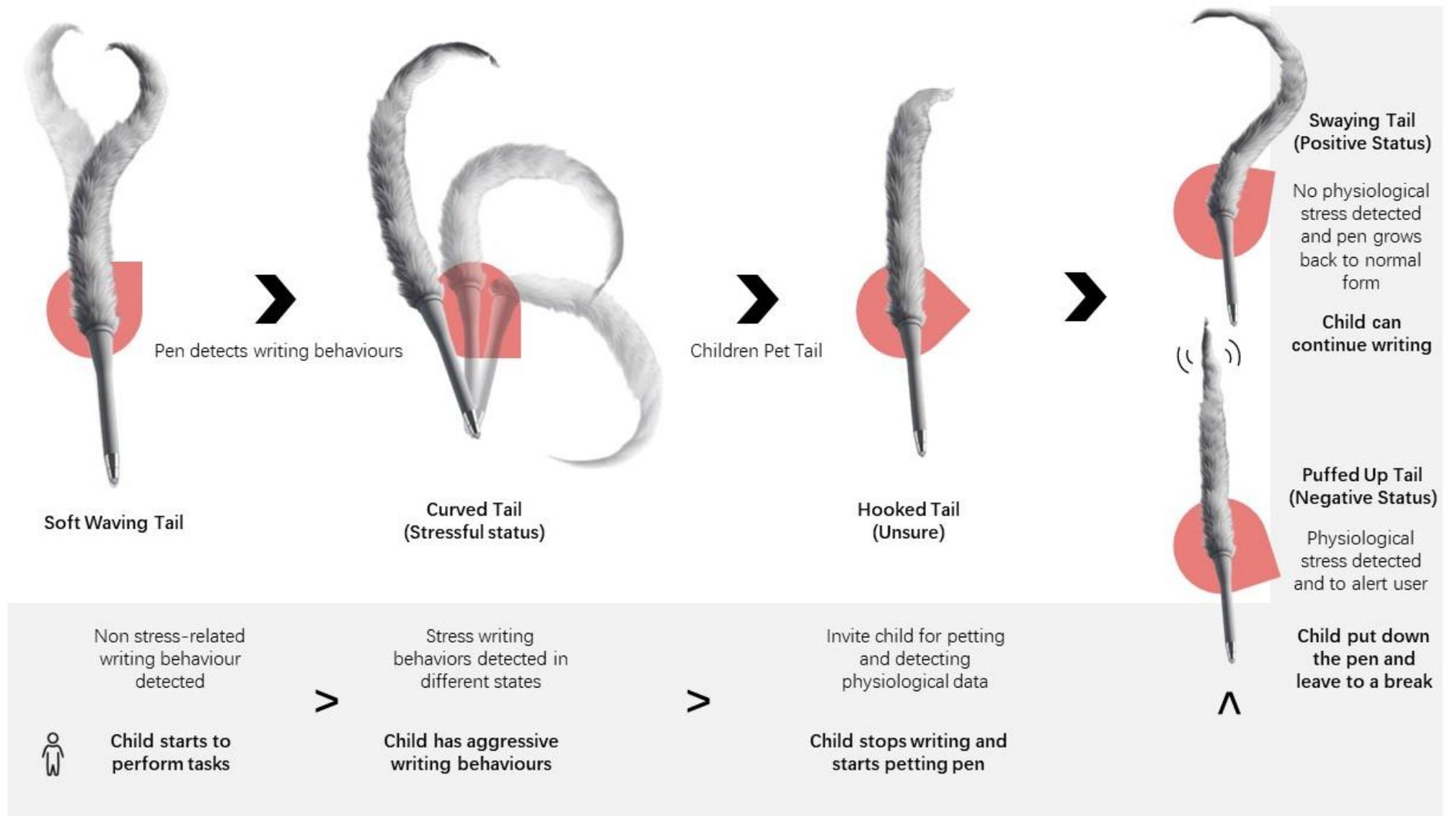


Figure 6. Child-Product Interaction map

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