

Paper:

# Robot Therapy for Prevention of Dementia at Home – Results of Preliminary Experiment

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**In robot therapy for senile dementia patients, a seal-like robot, Paro, was left in patients' homes for a week to determine its neuropsychological influence. Efficacy was evaluated by the diagnosis method of neuronal dysfunction (DIMENSION), which detects a lack of smoothness of scalp potential distribution resulting from cortical neuronal impairment by analyzing recorded a patient's electroencephalogram (EEG). Interaction with Paro by patients was observed by their families. In a preliminary experiment, 5 subjects were studied after informed consent was received from them or their families in accordance with the medical ethics committee of the University of Tsukuba and the AIST ethics committee.**

**Keywords:** mental commitment robot, robot therapy, psychotherapy, human-robot interaction, dementia

## 1. Introduction

Robot therapy has attracted robotics researchers, psychologists, medical doctors, and so on [1–25]. Anticipating that interaction with robot animals would encourage people to interact as they would with real animals. In the United States, where animal therapy is becoming widely used in hospitals and nursing homes [26, 27], such therapy is expected to have 3 effects:

- 1) *Psychological, e.g., relaxation, motivation*
- 2) *Physiological, e.g., improved vital signs*
- 3) *Social, e.g., stimulation of communication among in-patients and caregivers*

Few hospitals and nursing homes in Japan accept animals, despite the positive effects of animal therapy. They worry about negative – allergy, infection, bites, and scratches.

In our work in robot therapy since 1996 [1–18], we have proposed a mental commitment robot that provides mental effects such as joy, happiness, and relaxation to people through physical interaction. We developed a seal-like mental commitment robot named Paro for robot therapy, and used it at pediatric hospitals and facilities for

the elderly, such as day service centers and health service facilities for the aged [8–12]. Results showed that interaction with Paro improved patients' and elderly people's moods, making them more active and communicative with each other and their caregivers. Results of urinary tests showed that interaction with Paro reduced stress among the elderly [11]. We investigated long-term interaction between Paro and the elderly and found that effects of interaction with Paro lasted for more a year [12]. Neuropsychological effects of Paro on patients with senile dementia were assessed by analyzing their electroencephalograms (EEGs) [13]. Results showed that the activity of patients' cortical neurons improved through interaction with Paro, especially in those who liked Paro.

Dautenhahn used mobile robots and Robins robotic dolls for therapy with autistic children [19, 20]. Other robot animals, such as Furby, AIBO [28], and NeCoRo, have been commercialized and robot therapy using these robots attempted [21–25]. Yokoyama used AIBO in a pediatrics ward and observed the interaction between AIBO and children [21]. He pointed out that when people met AIBO for the first time, they were briefly interested, but relaxation effects such as those obtained from petting a real dog were never felt with AIBO. Kanamori et al. examined the relationship between interaction with AIBO and loneliness in the elderly in a nursing home [24]. Tamura et al. also used AIBO for 5 minutes with patients exhibiting dementia and compared its effects with those of a toy dog [25]. No studies have, however, to our knowledge, studied the neuropsychological influence of robot therapy at home on patients with dementia Except our previous study above. Even this study only assessed the effects of 20 minute interaction with Paro at a hospital.

We observed interaction between the seal robot Paro and patients with dementia, observing their behavior and neuropsychological effects at home using EEGs, as detailed in the sections that follow.

This paper is organized as follows: Section 2 introduces the seal robot Paro used in robot therapy. Section 3 examines describes dementia. Section 4 covers the diagnosis method of neuronal dysfunction (DIMENSION), a type of EEG analysis, used to evaluate efficacy. Section 5 discusses experimental methods and results and current

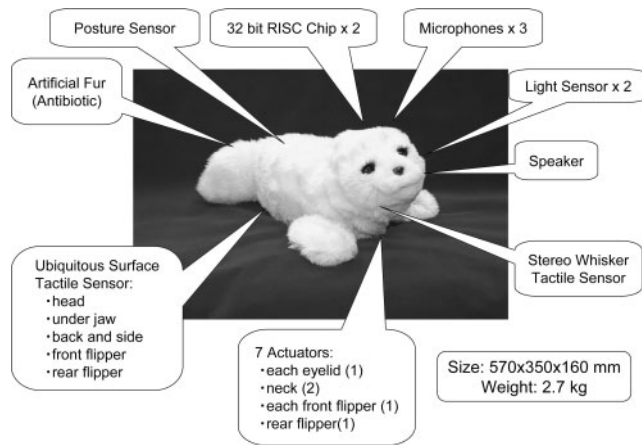


Fig. 1. Paro, the seal robot.

results of robot therapy and projected work. Section 6 presents conclusions.

## 2. Seal Robot Paro

The seal robot Paro (Fig. 1) was designed based on a baby harp seal, and is covered with pure white fur. Ubiquitous surface tactile sensors between the hard inner skeleton and the fur create a soft, natural feel and measure user contact with Paro [17]. Paro has four primary senses – sight (light sensors), audition (determination of sound source direction and speech recognition), balance, and tactile sense. It moves its neck vertically and horizontally, its front and rear flippers, and its independent eyelids, which is important in creating facial expressions. Paro weighs 2.8 kg and operates about 1 hour on a battery. Paro continues to operate when a charger, shaped like a pacifier, is used.

Paro's behavior consists of two hierarchical proactive and reactive Layers producing three types of behavior: proactive, reactive, and physiological.

### 2.1. Proactive Behavior

Paro's behavior-planning and behavior-generation layers produce proactive behavior by addressing its internal states of stimulation, desires, and rhythm.

#### 2.1.1. Behavior-Planning Layer

The behavior-planning layer is a state transition network based on Paro's internal states and desires, produced by its internal rhythm. Paro's internal states are described as emotions. Each state has a numerical level that changes based on stimulation. Each state decays with time. Interaction changes its internal states, producing Paro's "character." The behavior-planning layer sends basic behavioral patterns to the behavior-generation layer, including several poses and movements. Despite the term "proactive," Paro's proactive behavior is very primitive compared to its human counterpart. We programmed Paro so that its behavior resembled that of a real seal.

#### 2.1.2. Behavior-Generation Layer

The behavior-generation layer produces control references for actuators to produce predetermined behavior based on the strength of internal states and their variations. Different parameters, for example, change the speed of movement and the number of instances of the same behavior, so although the number of basic patterns is limited, the number of emerging behaviors is infinite because of the varying number of parameters. This creates life-like behavior. To draw attention, the behavior-generation layer adjusts parameters based on the priority of reactive and proactive behavior based on the strength of internal states, contributing to Paro's behavior and making it difficult for users to predict Paro's actions.

#### 2.1.3. Long-Term Memory

Paro uses reinforcement learning, placing positive value on preferred stimulation such as stroking and negative value on undesired stimulation such as hitting. Paro assigns values to relationships between stimulation and behavior. Users cannot change Paro's behavior program manually, although Paro can be gradually trained into the behavior preferences of its user. Paro memorizes a frequently articulated word as its new name. Users can give Paro a name during natural interaction.

### 2.2. Reactive Behavior

Paro reacts to sudden stimulation, looking in the direction of a sudden loud sound, for example. Several patterns of combinations of stimulation and reaction are assumed to be behavior that is conditioned and unconscious.

### 2.3. Physiological Behavior

Paro has a diurnal rhythm and spontaneous needs such as sleep based on this rhythm.

We conducted studies using questionnaires at exhibitions in six countries – Japan, the U.K., Sweden, Italy, Korea, and Brunei – to determine how people evaluated the robot. Results showed that Paro was widely accepted across cultures [18].

## 3. Dementia

Dementia is an increasingly important issue in the care of the elderly. Alzheimer's disease International (ADI) estimates that 24.4 million people worldwide suffer from dementia, and that the number of patients will increase to 82 million by 2040. Dementia is a progressive disabling neurological condition seen in a wide variety of diseases. Its most common form is Alzheimer's disease, which accounts for half of all dementia patients, followed by vascular disease, Lewy body dementia, and many other dementia-triggering diseases [29]. Dementia is not a natural part of aging but age is its most significant known risk factor. Over the age of 65, the risk of developing dementia doubles every five years [30]. Psychiatric and behavioral disturbances such as personality change, hallucinations, paranoia, aggression, wandering, and incontinence