The Ontogenetic Adaptation in Behavioral Development in Post-weaning Pre-juvenile Rats[1]

Kunio Miyamoto

Introduction

Researchers might take the perspective of the process from immaturity to maturity in studying the development of behavior. Further, they supposedly predispose that the behaviors of developing animals are the precursors to the perfect adult type of behavior. But in recent years, the concept of ontogenetic adaptation has been advocated (Oppenheim, 1981; Alberts, 1987).

It is suggested that development involves both qualitative and quantitative changes in body, brain, and behavior. These changes involve addition and deletion of features, responsiveness and capabilities. Therefore, development does not progress uniformly. For example, mammals undergo a fetus period in the uterus and proceed to the nesting maternal environment of pre-weaning period. After weaning, they gradually develop into the independent nutritional stage. These developmental stages differ tremendously between species but developing organisms are adaptive to their ecological niche and their behavior patterns are a complete system at each developmental stage. The concept of ontogenetic adaptation shows that immature animals are not merely miniature and incomplete version of adults, but are competent organisms that sense and interact with their environment, and exhibit specialized behavioral and physiological attributes that help them to survive within that environment (Smotherman & Robinson, 1998).

The fitnesses of different genotypes are perhaps the most important variables in the theory of evolution. They determine, to a large extent, which genotypes we can expect to see in the world today. The fitness of a genotype measures its relative ability to reproduce itself, compared to other genotypes. Fitness shows to what extent a genotype is favored by natural selection (Ridley, 2003). An adaptive-evolutionary view of development supports the above mentioned perspectives by noting that natural selection can operate at each point in development, not solely on the adult (Alberts, 1987; 1999).

The purpose of this report is to demonstrate the ontogenetic adaptation of post-weaning and pre-juvenile rats by showing the dual aspects of behavioral development and considering the way in which these young rats meet their need by interacting with their immediate environment. We advance the concept of ontogenetic adaptation into general tendency and specific behavior patterns by considering the results of the five studies on behavioral development of rats, including hoarding

behavior, predatory behavior, radial maze learning and emotional reactivity using the Runway Test and novel/ aversive stimulations.

General Method

The subjects in the experiments were weaning (25 days), post-weaning (30-35 days), juvenile (40 days) and adult (60 days and 90-120 days) female and male Wistar rats. Hoarding behavior, predatory behavior, radial maze learning, runway behavior, and responsiveness to novel taste solutions, to loud noises and to electric shocks were observed for 5 or 6 days. The results of the 5 experiments were discussed with specific reference to the concept of ontogenetic adaptation in the behavioral development of rats.

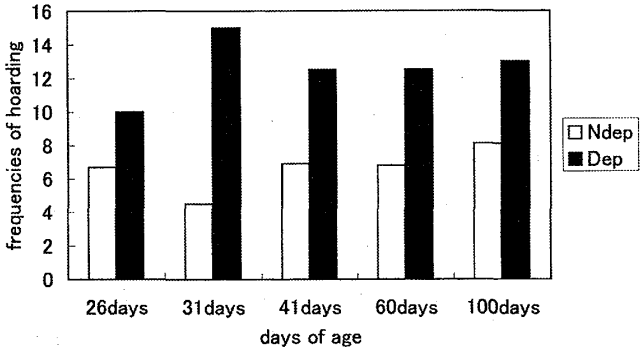

Fig.1 Mean frequencies of hoarding responses in deprived and non-deprived rats of different ages.

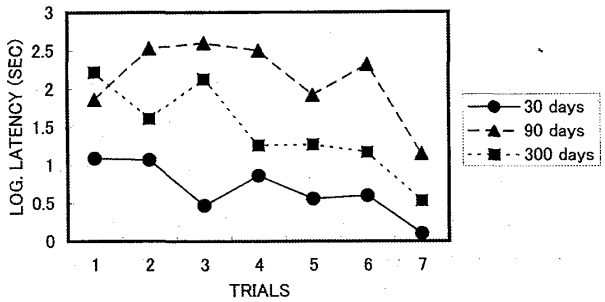

Fig.2 Mean log. latency to attack the prey in rats of different ages.

Study 1 Hoarding behavior (Miyamoto, 1989)

Food hoarding behavior of laboratory female and male rats was observed in different ages (26, 31, 41, 60, 100 days) for 6 days. Rats were required to hoard food pellets from the end of the alley to the adjacent home cage. After the adaptation period to the apparatus for 5 days, the deprived and non-deprived rats were tested of pellets-hoarding behavior under dark condition for 30 min, and then the cumulative numbers of hoarded pellets were recorded 21 hrs later. On Day 6, they were tested under deprived conditions.

According to Fig.1, the mean frequencies of hoarding responses increased with age except 30-days rats. They scattered pellets on the alley, showing lower level of hoarding compored to older rats. But the deprivation of food activated the

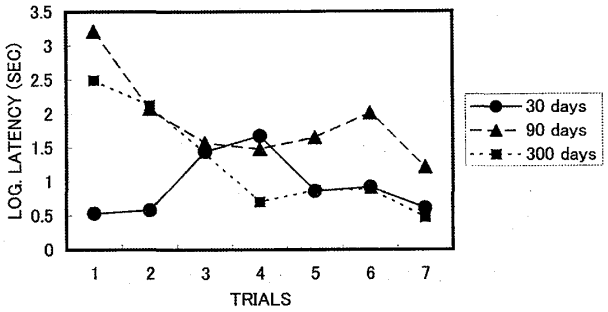

Fig.3 Mean log. latency to eat the prey in rats of different ages.

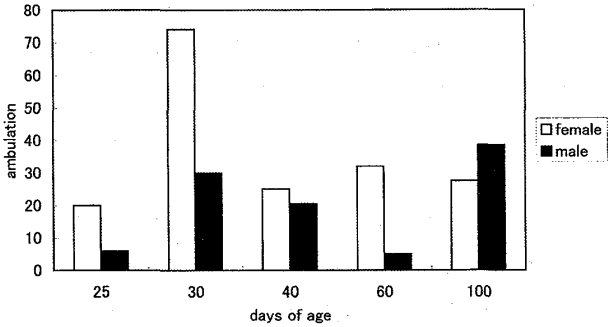

Fig.4 Mean numbers of sections traversed on three days of RunwayTest in 5 different age groups (Miyamoto,1997).

hoarding behavior, as did the older rats. Further, pellet-droppings were frequently observed in 25- and 30-days rats, indicating unskillful handling in these young pups.

Study 2 Predatory behavior (Miyamoto, 1995)

Predatory behavior of laboratory female and male rats were observed in different ages (30, 90, 300 days) for 7 successive days. A prey insect was presented to the deprived subject in their individual cage, and the predatory behavior was observed for 30 min. Crickets were used as preys and the latency to discover, to attack and to eat them, and the total eating time were recorded.

Post-weaning 30-days rats discovered the prey most rapidly and attacked quickly (Fig.2). They began to eat the prey more rapidly on 1st and 2nd trials (Fig.3). But the differences of the eating time between the age groups were not significant. These results suggest that post-weaning pre-juvenile rats are most effective predators in spite of the handicap caused by large size of preys relative to their body size.

Study 3 Runway behavior (Miyamoto, 1997)

The developmental changes of emotional reactivity of rats were investigated in two experiments using the Runway Test at different ages (20, 30, 40, 60, 90 days). The subjects were put into the starting box for 30 sec, then the guillotine door was opened to an adjacent runway and the latency to enter runway, numbers of sections

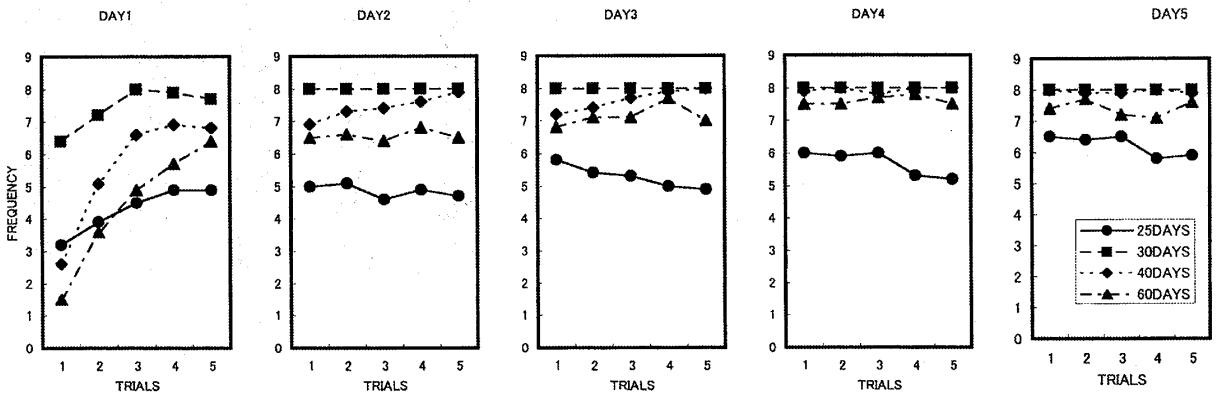

Fig.5 Mean frequencies of correct responses in each age group in 5 days of 5 trials.

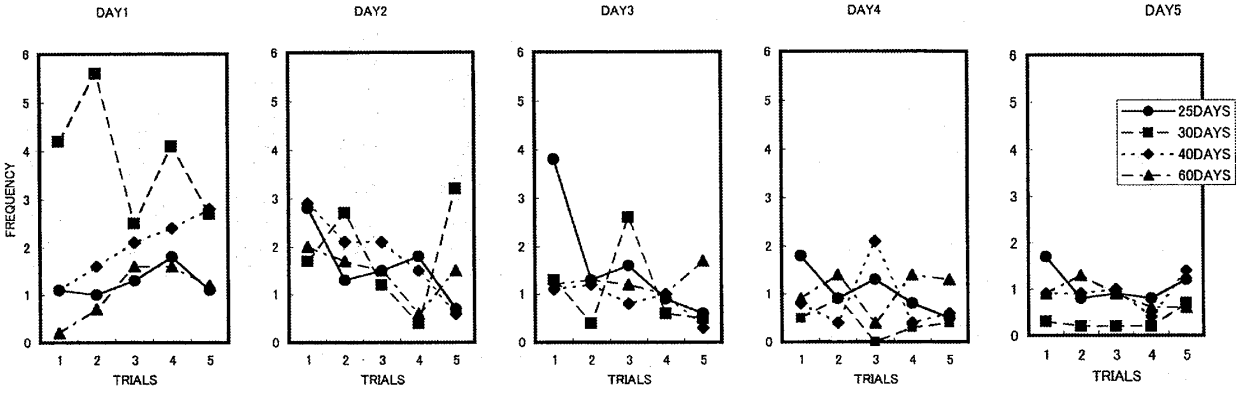

Fig.6 Mean frequencies of errors in each age group in 5 days of 5 trials.

traversed, defecation and urination were recorded for 5 min. Tests were run for 3 consecutive days.

Cross-sectional comparison of behavior showed that 30-day-old rats entered a runway region faster, reached the end section faster, and traversed more sections than other age groups (Fig.4). Rats 60 and 90 days of age defecated boles more and urinated more. Secondly, longitudinal comparison showed that the ambulation of 30 and 40-day-old rats increased gradually over test days, but 60 and 90-day-old rats showed no increase of ambulation and less defecation. These results suggested that post-weaning, pre-juvenile rats are less emotional in novel situations.

Study 4 Radial maze learning (Miyamoto, 2000a)

The developmental changes of radial maze learning of Wistar male rats were examined in different ages (25, 30, 40, 60 days). The 18 hrs-deprived subjects were trained in the 8-armed radial maze, on 5 trials/day for 5 days. The subjects were required to get a reward of pellets at the end of 8 arms with maximum latency of 3 min. The inter trial interval was 20-30min.

Fig.5 shows that the number of correct responses of 30-days rats decreased most rapidly but they were most erroneous (Fig.6). Further, it was found that they were the most rapid learners. These results suggest that the high level of activity of post-weaning pre-juvenile rats might lead to the high level of performance.

Study 5 Responsiveness to novel taste solutions, to loud noises and to electric shocks (Miyamoto, 2000b)

The developmental changes of emotional reactivity in Wistar rats were investigated by using the indices of responses to two novel taste solutions, to loud noises and to electric shocks. We selected two kinds of novel solutions, less preferred oolong and more preferred cocacola. The subjects were tested their preference/aversion of the novel solutions and tap water in their individual cage using two-bottles-choice method for 24 hrs.

In the second experiment, the shuttle box avoidance apparatus and computer system were used to produce noise

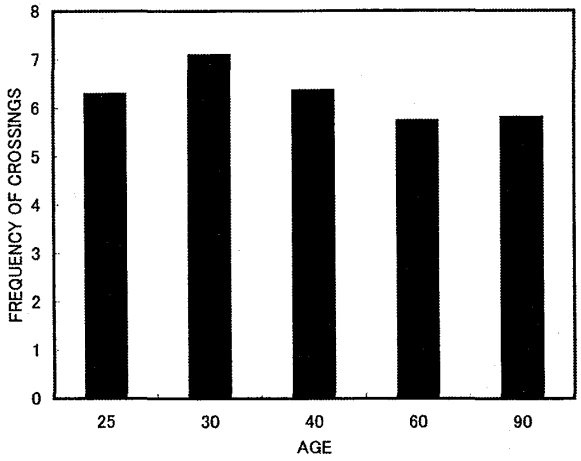

Fig.7 Mean frequencies of crossings over two compartments after sound stimulation in rats of different ages.

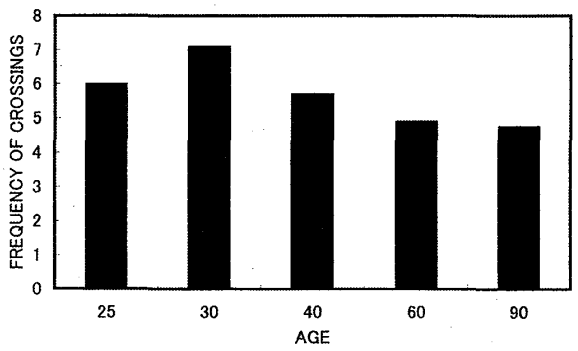

Fig.8 Mean frequencies of crossings over two compartments after electric shocks in rats of different ages.

and shocks and the latency of subjects to cross the compartments and the numbers of crossings were recorded. The subject rats in the experiments were 25, 30, 40, 60 and 90-120 days of age.

Post-weaning pre-juvenile rats (30 days) showed short latency to be active and a high level of activity after the stimulation of loud noises (Fig.7) and electric shocks (Fig.8), suggesting relatively rapid habituation. Any indication of neophobia to the novel solutions could not be found. These data implied a post-weaning temporary reduction of emotional reactivity to the aversive stimulation.

Discussion

According to Alberts (1987), the concept of ontogenetic adaptation can be applied to the development of behavior, if 1) there are some transient changes in some aspects of developmental process, 2) those developmental changes correspond to their ecological niches, and 3) functional relations are found between the behavior of organisms and their environment. Examples of ontogenetic adaptation were listed below, play behavior (Oppenheim, 1981), transition from suckling to adult ingestion (Galef, 1981), lack of taste aversion in pre-weaning infant rats (Alberts, 1987), thermoregulatory behavior (Alberts, 1999).

Results of our studies suggest that behavioral characteristics of post-weaning pre-juvenile (30 days of age) rats were related to the lowered level of emotional reactivity, rapid learning and adaptation to various tasks compared with the other age rats. We consider these behavioral characteristics of this age to be the case of ontogenetic adaptation in this species.

The vital tasks that weaning rats face are to go out from their borrows, explore the outer environment, find food and return to their home borrows safely in their natural habitats. The exploratory behavior in the novel environments might be suppressed by their emotional reactivity. The temporary reduction of emotional reactivity will be adaptive in facilitating their exploratory behavior, foraging for food, and shaping the cognitive map around the home borrows. It is the post-weaning pre-juvenile period when the first foraging excursion from their home borrows start.

It will be productive to introduce the concept of specific ontogenetic adaptation as well as general non-specific adaptation in order to apply the concept into developmental studies of animal behavior. General nonspecific adaptation is regarded as developmental changes of general characteristics or tendency such as emotional reactivity, on the other hand specific ontogenetic adaptation refers to specific perceptual or motor skills, such as responses-emitting strategy in learning radial maze tasks. In the experiments of early behaviors of developing rats, we can list up both aspects of ontogenetic adaptation.

General nonspecific ontogenetic adaptations were: 1) Temporary reduction of emotional reactivity and augmentation of exploration, 2) Responsiveness and rapid habituation

to aversive stimulations. Specific ontogenetic adaptations were: 1) Pellets-droppings and inability to locate, 2) Responses-emitting strategy in maze learning.

We need some explanation about the latter terminology. As to pellets-droppings and inability to locate, pellets-droppings cause food scattered around the nest borrows. Pre-weaning and weaning rats are difficult to locate food pellets once missing them because of their attention deficits (Miyamoto, 1997). Therefore, foods-scattered situation are rather convenient for developing rats to feed. As to the responses-emitting strategy in maze learning, by adopting the sequential fixed action patterns, it might be more adaptive to reset the long lasting task and to repeat a simple trial-and-error response with short latency for developing rats of this age that have limited duration of working memories.

The dual properties of ontogenetic adaptation in developing organisms, general tendencies of behavior and motor skills reflecting the sensory-motor developmental stages interact with their immediate environment, promoting the adaptation to their developmental niche. These considerations of ontogenetic adaptations will give us quite useful tools creating the hypothesis and studying the interaction between developmental ecological environment and individual maturation.

Notes

1. This report was based on the papers presented at the 28th International Congress of Psychology. Beijing, China (2004, August).

Summary

Several aspects of behavioral development were examined in rats in five experiments. Food hoarding of 30-day-old rats was at the lowest level, facilitated by hunger. Crickets-predation was best performed in 30-days rats. Runway emergence and responsiveness to aversive stimuli (electric shocks and loud noises) of the same age rats suggested that they were less emotional. The performances of radial maze learning of these rats were at the lowest level, showed active responding strategy different from other age rats. These findings suggest the ontogenetic adaptation of post-weaning, pre-juvenile rats in terms of general tendency as well as specific behavioral properties.

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