

Validation of a Behavioral Task to Study Perceptual Supplementation in Rats

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Abstract

This research validates a rodent model for perceptual supplementation (or sensory substitution). DA/Han rats were video-tracked in the darkness and had to find a reward by searching an auditory virtual track. Through the 3 stages of the experiment, rats learned to use the auditory feedback to follow the virtual track and reach the reward. Our results indicate that perceptual supplementation is possible in rats and our task could be adapted in order to study the mechanisms of perceptual supplementation and its ontogeny and neurobiological substrates.

Keywords: sensory substitution, perceptual supplementation, rats, behavior, learning

Introduction

Perceptual supplementation, also referred to as sensory substitution, is the process by which an individual can experiment its environment through unexpected sensations. For instance, the Tactile Vision Sensory System (TVSS) developed by Paul Bach-y-Rita allows blind people to perceive their outer world by manipulating a camera which, in return, sends tactile stimulations to the skin through a computerized device (Bach-y-Rita, 1969). Similarly, TACTOS was designed to study visuo-tactile exploration of a virtual environment (Ziat et al., 2007). By using TACTOS, a blind person is able to perceive shapes by moving a stylus on a graphics tablet and by receiving a tactile stimulation through a Braille cell every time the stylus runs over the line of a shape. The aim of our study was to develop a comparable situation of perceptual supplementation in rats. In this research, rats were video-tracked in darkness and they had to learn how to reach a reward by relying on an auditory signal that was played each time their snout entered a virtual track guiding to the reward. The present paper reports the protocol as well as the results that evidence for the first time the possibility of a perceptual supplementation process in rats.

Methods

DA/Han males rats (n=6) were tested from the age of 8 weeks. Animals were maintained in groups of 3 in standard cages with free access to food *ad libitum* (lights from 00:00 to 12:00). Behavioral testing took place from 13:00 to 16:00 and water access was restricted to 2 hours per day after the behavioral testing. Rats were tested in a 1m diameter semi-circular arena (Figure 1). The experimental room was totally dark and an ANY-maze® video-tracking system (Stoelting Co, Wood Dale, IL – version 4.89) tracked their movements under infrared lightening (3 projectors with 15 LEDs each). Each time the snout of the animal entered the correct virtual track among 3 possible, a speaker controlled by the ANY-maze interface played a continuous sound of 4 kHz and 55 dB. The sound by itself carried no spatial information on the reward location. When the snout of the animal reached the end of the track, a water reward was delivered at the floor level through a steel canula. The next trial started automatically when the animal reached back the intersection of the three possible virtual tracks.

The experiment was composed of 3 stages (see Figure 1). On each day of each stage, there were 40 trials given in 2 sessions of 20 trials with an intersession of approximately 30 minutes. For each trial, the correct track was randomly chosen by ANY-maze.

Stage 1 lasted 8 days and was conducted in a 3 closed arms maze. For each trial, rats learned to find the reward at the end of the arm that was auditory cued. Trials had no limit of time.

Stage 2 was 7 days long and took place in the semi-circular arena with 3 possible virtual tracks (same positions than the closed arms on stage 1). For each trial, rats had to use the sound played when their snout entered the correct virtual track to reach the reward. In order to limit alternate strategies and force the animal to use the auditory feedback, the reward was delivered only if the rat had entered both the proximal and the distal part of the track. Trial duration in stage 2 was limited to 45 seconds.

Stage 3 lasted 4 days. On the 3 first days, rats had to learn a new configuration of the tracks since the left and right ones were moved to an oblique position. On day 4, the auditory feedback was not played anymore in order to provide a good control to the experiment. Trials were still limited to 45 seconds.

Ethical statement: The research reported in this paper was conducted in accordance with the European council directive for the protection of animals used for experimental and other scientific purposes (EC86/609).

Results

Rats first learned to use the sound in the 3 arms maze. The number of errors, indicated by the number of time they went to the end of an arm not rewarded and not cued by the auditory feedback, decreased significantly in day 6, 7 and 8 compared to Day 1. On stage 2 (See Figure 2), the mean percentage of successful trials increased over days to reach a performance of 92.1% on day 7. This percentage was significantly more important than on day 1, 2 and 3. When the positions of two lateral tracks were changed on stage 3 (See Figure 3), the rats' performance dropped to 40% but reached 87.5% of success on day 3. On day 4 of stage 3, when the auditory feedback was removed, the rats' performance dropped to 47.5% (See Figure 3, white histogram).

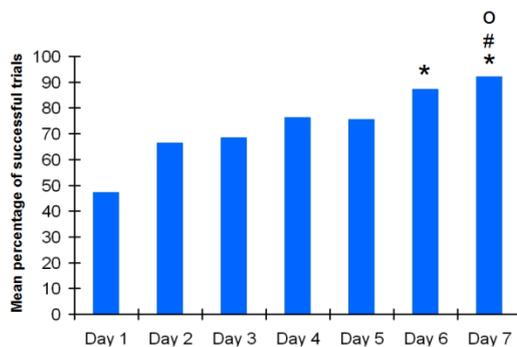


Figure 2. Mean percentage of success during stage 2. * $p < 0.05$ in comparison to day 1; # $p < 0.05$ in comparison to day 2; o $p < 0.05$ in comparison to day 3.

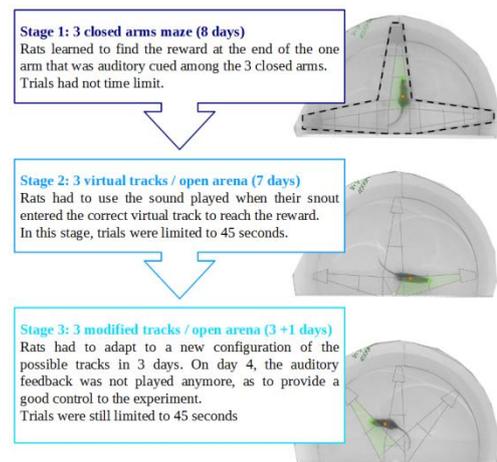


Figure 1. Illustration of the apparatus, tracking and schedule of the behavioral protocol. The 3 stages ran over 19 consecutive days. Dotted lines on the 1st stage indicate the position of the closed arms.

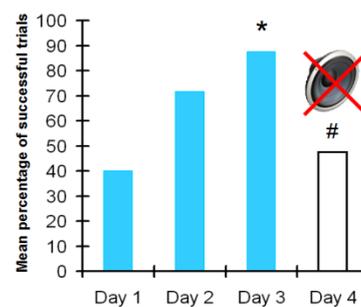


Figure 3. Mean percentage of success during stage 3. * $p < 0.05$ in comparison to day 1; # $p < 0.05$ in comparison to the day 3.

Discussion

Our research describes a valid protocol to study perceptual supplementation in rats. Animals learned to use efficiently the sound feedback to find the reward in all three stages of the experiment and, on the last day of stage 3, the percentage of success dropped drastically when the auditory feedback was removed. However, since 47% of the trials were still successful, it is probable that other information, such as idiothetic spatial information, were also used in this form of perceptual supplementation. In conclusion, our behavioral task may prove its importance

in order to study the conditions that lead to perceptual supplementation as well as the ontogeny and the neurobiological substrates of this process.