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Research report

Motion perception in rats (*Rattus norvegicus* sp.): Deficits in albino Wistar rats compared to pigmented Long-Evans rats

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Abstract

Motion perception was tested in pigmented Long-Evans and albino Wistar rats (*Rattus norvegicus* sp.) using moving random dot patterns. Pigmented as well as albino rats could distinguish a fully coherently moving pattern from dynamic noise. However, motion coherence thresholds were significantly lower in pigmented compared to albino rats (12% and 30% coherence, respectively). These results indicate that pigmented rats have well developed motion coherence perception, whereas albino rats are severely impaired but not motion blind.

Keywords: Albinism; Visual; Motion detection; Motion coherence; Rodents

Albino mammals are an important model for studying the development, function and pathology of the visual system [18]. The albino phenotype is characterized by reduced pigmentation of the skin, iris and retinal pigment epithelium. The reduced action of the enzyme tyrosinase leads to a lack of L-DOPA (L-3,4-dihydroxyphenylalanine) which in turn causes a cascade of spatiotemporal perturbations during retinal development [18]. These maturational alterations lead, e.g. to a reduced number and a reduced peak density of rods, a reduced ipsilateral projection of ganglion cell axons, as well as physiological deficits in cortical visual centres [3,8,17]. These anatomical changes result in various visual perception deficits [1,4,10,11].

Albino mammals have reduced visual acuity, depth perception and a limited monocular visual field. They also show various impairements in their optokinetic reaction, i.e. their ability to stabilize the image of the environment on the retina [7,14]. In albino Wistar rats, the optokinetic reaction is strongly reduced or absent [27,31]. The rat, together with the mouse, is an important laboratory animal serving for many pathological studies. Various strains including models for degenerative deficits of the visual system are available. As the visual system of this species is being studied more thoroughly, the animals' visual capacities have to be analysed in detail also on the behavioural level. We therefore investigated whether albino rats have a deficit in visual motion perception which could explain their optokinetic deficit, thus whether albino rats are motion blind.

1. Animals

The investigation of motion perception in albinos was started with eight experienced Wistar rats (ALB_e: four males and four females). They had previous experience with the setup and the training stimuli and were 12-months old at the beginning of the experiments. Then two other age matched groups of naive Wistar (ALB_n: two males and two females) and black-hooded Long-Evans rats ($PIGM_n$: four males and four females), 12–20 weeks old at the beginning of the training, were tested for their motion coherence threshold. Five Long-Evans rats were bred and raised at the animal facility of our institute, three female Long-Evans rats were bought from a commercial breeder (Harlan UK, strain Hsd:Blu). Wistar rats were bred and raised in the departmental animal facility, and were offspring of parents derived from Harlan Winkelmann, Hannover (strain: Wistar Unilever Hsd-Cpb). All rats were grouphoused in environmentally enriched (60 cm × 50 cm × 50 cm) cages under natural daylight. The rats could avoid exposure to light by hiding in wooden huts, which were placed beneath opaque shelves covering about a third of the floor area, to provide maximal protection from light. Light intensities inside the cages were below 50 cd/m^2 at ground level and below 20 cd/m^2 in front of their huts. These light intensities are significantly lower than under conventional housing

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conditions with artificial light (100–200 cd/m^2). Rats were food-deprived and kept at a minimum of 85% of their free feeding body weight. Water was available ad libidum in the homecages. All experiments were conducted in accordance with the European Communities Council Directive of 24 November 1986 (S6 609 EEC) and the National Institutes of Health guidelines for the care and use of animals for experimental procedures. The experiments were approved by the local ethics committee.

2. Setup and procedure

A two alternative forced choice paradigm was used in a modified Lashley jumping stand (Fig. 1). The setup consisted of a wooden box with a small central platform, high above the ground in the centre of the box, and two choice platforms in front of a monitor. Stimuli were presented side by side on the monitor, creating a left–right choice situation. Operant behaviour of the rat consisted of crossing the gap by stepping over to one of the choice platforms. In case of a correct choice, the rat was rewarded by single sunflower seeds, a false choice resulted in no food reward. Rats were handled for 2 weeks and habituated to the setup and the sunflower seeds used as reward. The experiments began with a handshaping to the desired operant behaviour after which the first visual discrimination stimulus was introduced. Usually 30–40 trials per session were performed by trained rats, after each session rats received additional food in a separate cage.

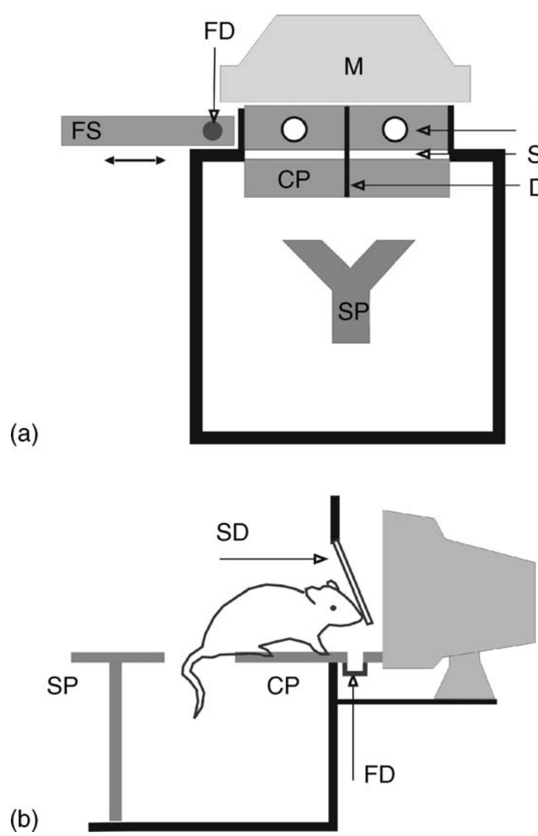

Fig. 1. Illustration of visual discrimination setup: (a) setup illustrated as seen from above and (b) illustration of the setup as seen from the right. Elements: CP, choice platforms (left, right); D, divider; FD, food dish; FH, food hole; FS, food slide; M, monitor; SD, swinging door; SP, start platform. A horizontal start platform (SP) is adjusted in half height inside a wooden box. The monitor (M) outside the box can be watched by the rat through a rectangular opening. The left and right choice platforms (CP), adjusted at the same height as the central platform, are separated from each other by an opaque vertical divider (D). The swinging door (SD) can be pushed towards the monitor (see (b)), allowing access to the food holes (FH). The food slide (FS) can be moved so that the food dish (FD), containing a single sunflower seed, is placed below the corresponding food hole (FH).

3. Stimuli

Limited lifetime moving random dot patterns were created and presented by the software “randomdots”, developed by B. Krekelberg. Dots were white squares, $2^\circ \times 2^\circ$ in size, mean dot density was 0.1 dots/deg^2 and the visible area of the stimulus was $35^\circ \times 35^\circ$ for each side. Dot speed was kept at $10^\circ\ s^{-1}$, lifetime of each dot was limited to 1 s, after which the dot vanished and was replaced at a new random position. A coherent movement was created by a proportion of dots moving to the right. Equal proportions of dots moving in different directions created an incoherently moving dynamic noise pattern. The proportion of coherently moving dots among dynamic noise is referred to as percentage of coherence. A strong avoidance reaction of the rats to the coherent stimulus was observed, the dynamic noise pattern was chosen as the rewarded stimulus (S+). Rats were initially trained to discriminate a dynamic noise pattern (0% coherence) from a black (B) screen. This first training level is referred to as 0|B, indicating the type of S+ and S− (S+|S−), and was followed by several training levels during which dot density of S− was increased from 0 to the final dot density. Once criterion performance was reached, which was set to 80% correct choices over two sessions of at least 20 trials each, the next training level began. Motion coherence detection ability was finally investigated with a stimulus of 0% versus 100% coherence.

For the second experiment, the method of constant stimuli was used to obtain motion coherence thresholds from Wistar and Long-Evans rats. Stimulus intensity (i.e. percentage of coherence) of S− was varied, 11 levels (5% and values between 10% and 100% coherence in steps of 10%), were presented versus 0% coherence as reference stimulus. Sets of four coherence values were presented in randomised order within one session, sets were changed between sessions.

4. Analysis

Target and choice positions for each trial were protocolled by hand. The outcome of a training session was given as percentage of correct choices over all trials. The mean percentage of correct choices was calculated over at least 100 trials for level 0|B and 0|100 and for about 60 trials per level for motion coherence threshold assessment. The threshold was determined as the percentage of coherence at criterion performance, which was calculated individually as the mean between lapse rate (best performance) and guess rate (50% correct choices), resulting in about 70% correct choices. Statistical analysis consisted of comparing performance of albino and pigmented rats using the