

Mice can learn roughness discrimination with vibrissae in a jump stand apparatus

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Abstract. An adaptation of roughness discrimination task successfully used on rats was performed on mice. It was found that mice can master discrimination of rough surfaces using only mystacial vibrissae. This task can be used for studying sensory abilities of genetically modified mice as well as dynamics and pharmacology of complex sensory learning.

Key words: tactile learning, mice, vibrissae

The rodent somatic sensory system is characterized by a prominent representation of the mystacial vibrissae (Woolsey and Van der Loos 1970). The mystacial vibrissae, the long sinus hair of the snout of a variety of rodent species, function as an array of mobile tactile sensors that is used actively to obtain information about the form and texture of the animal's environment. Individual vibrissa is scanned across object surfaces in repetitive, saccade-like "whisks" (Welker 1964, Carvell and Simons 1990). Mystacial vibrissae are active during exploratory and discriminative behaviour. Acute removal of the vibrissae results in deficits in tactile discrimination, orientation, locomotion and balance (Vincent 1912)

It is known that rats are able to learn a rough-smooth discrimination task by actively palpating the discriminanda (e.g. sandpaper surfaces, grooved plastic cylinders) with their vibrissae (Guic-Robles et al. 1989, Carvell and Simons 1990). But no experiments with the roughness task discrimination with tactile information coming exclusively from the vibrissae were made on mice. The use of mice in brain research is increasingly important because of possibility of using tools of molecular biology and genetics. Additionally, the vibrissae representations in the brain have special cytoarchitectonics, which renders them especially suitable for cell biological and molecular studies. The aim of that study was to investigate if mice can learn to discriminate between two surfaces of different roughness using their vibrissae.

The subjects were 23 (15 females and 8 males) Swiss albino mice, two months old at the beginning of the training. Animals had *ad libitum* access to water in their home cages and just after completion of a daily session received standard laboratory chow 3 g per day/per mouse. No weight loss was observed.

Discrimination apparatus (Lashley jump stand, constructed as described by Carvell and Simons (1990) for rats and adjusted for mice) consisted of three wooden platforms (one start platform and two choice platforms) that were elevated 19 cm above a base (Fig. 1). The distance between the start platform and the choice platforms could be adjusted. The distance between choice platforms was adjusted in a way that mice couldn't reach both discriminanda simultaneously.

Discriminanda were made of sandpaper of different surfaces (rough – grain size 190 μm , smooth grain size 50 μm , size of each discriminandum – 2x7.5 cm) that were interchangeably attached to the front of choice platforms. The paper was obtained from producer (Mirka)

that used the same kind of glue for both types of roughness. A food reward (piece of a sweet cake, ~0.07 g) was placed at the end of each choice platform behind a guillotined gate. The gate was opened by the experimenter only for those trials where the animal made a correct choice.

The behavioural task required an animal to stretch across a gap in order to palpate with its vibrissae textured surfaces. The vibrissae protract to the front; it is impossible for the mouse to touch the choice platform with the nose or front paws. The mice were trained to distinguish between two different surfaces and to indicate its choice by jumping from the start platform to one of two reward platforms.

Animals in three groups were rewarded for choosing the platform having rough surface and in the other two groups – for choosing smoother surface. The mouse was placed on the start platform, which was initially positioned close to the choice platforms. As the training progressed, the distance between the start and choice platforms was gradually increased to 6-6.5 cm. At the initial sessions (5-10) mice were habituated to the apparatus: they were allowed to freely explore platforms for 2 min. During the first five sessions they were allowed to correct errors. Then mice were not allowed to correct errors and they were allowed a maximum 120 s to move from start platform onto a choice platform.

Animals were trained in darkness and received 20 trials/day. The location of the rough and smooth

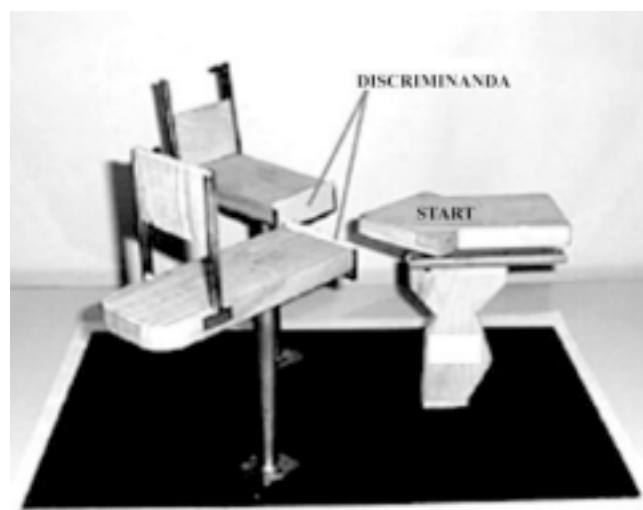


Fig.1. Modified jump stand for mice. Start platform - 17.5 by 8.5 cm., goal platforms - 20 cm by 7.5 cm. Platforms were elevated 19.5 cm above table surface. Platforms were made of solid wood and supported by solid metal construction.

discriminanda on the right or left choice platforms was randomized with the restriction that the reward stimulus not be located on the same choice platform initially for more than two consecutive trials and then for more than three consecutive trials.

An animal was considered to have successfully learned the discrimination task when it attained a score $\geq 80\%$ correct responses during consecutive three sessions.

At the initial sessions (5-10) mice were habituated to the discrimination apparatus and they learned to move from the start platform to choice platforms to receive a food reward. As training progressed, the distance between the start and choice platforms was gradually increased to 6-6.5 cm. It was the maximum distance that mice wanted to jump from the start platform to the choice platform. The distance between the start platform and the choice platforms was adjusted for each mouse.

Another 9-30 (on average 17.9) sessions of training were required for animals to attain the criterion level of performance in discriminating between two different sandpaper textures. Four mice (2 females and 2 males) did not attain the criterion level at all.

In some cases (9) mice exhibited progressive performance improvement over several session until finally reaching the 80% correct response criteria (Fig. 2A). In other mice (7) performance fluctuated near a chance level until exhibiting a fairly rapid increase in performance culminating in the 80% correct criteria (Fig. 2B). It is difficult to include the performance of the remaining three mice into one of this two different dynamics of the discrimination task learning.

Generally three strategies of solving the discrimination task were observed. (1) Mouse went straight to one of the choice platforms and did not palpate the discriminanda with its vibrissae. (2) Mouse moved to the edge of the start platform and palpated the discriminanda on the choice platforms with its vibrissae. Mice using the first strategy never reached the criterion level. There were at least two different types of the second strategy. (2a) Mouse always moved in the same direction (for instance to the right choice platform). (2b) Mouse moved in different directions. Then mice whisked the discriminanda and could change its position on the start platform so that it could palpate the other discriminanda. Sometimes mice repeated that sequences 1-2 times before jumping to a choice platform. There were only few cases that mouse did not jump onto the choice platform within allowed 2 minutes.

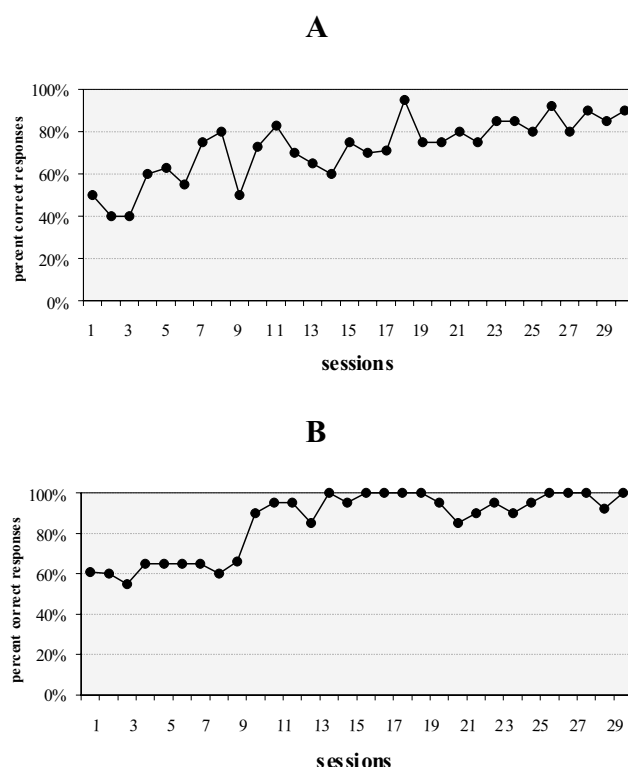


Fig. 2. Examples of two different dynamics in learning of the roughness discrimination task.

Mice can learn the discrimination task using only their vibrissae. They can use their mystacial vibrissae to obtain useful information about the surface texture of object in the environment. It is consistent with results of Guic-Robles et al. (1989) and Carvell and Simons (1990) obtained in the experiments performed on rats. It has been shown by Barenoud et al. (1991) that mice running in a jump stand use vibrissae to detect the presence of the goal platform. Lipp and Van der Loos (1991) constructed an automated Y-maze for analysis of vibrotactile discrimination, however, their construction did not eliminate touching the discriminanda with the nose. We present the first demonstration, in mice, of tactile discrimination only by touching with vibrissae.

Carvell and Simons (1990, 1995) observed that individual animals might differ with respect to the vibrissae movement strategies they employ in the discrimination tasks. Whisking patterns are correlated with the performance abilities of individual animals and with the nature of the surfaces being palpated (Carvell and Simons 1995). Some features of whisking behaviour appear to be associated with good discrimination ability, regard-

less of the nature of the surfaces being palpated. Individual animals differ with respect to both their overall sensory discrimination performance and their motor patterns (Carvell and Simons 1995). The present results show that mice might differ with respect to the strategies used in solving the discrimination task, too. Some mice failed with learning the task and it seems that it depended on employed strategy. Those mice went fast straight to one of the choice platforms and jumped onto it without palpating the discriminanda with their vibrissae. Such cases were not reported for rats, which may reflect a difference in excitability between the two species. The difference of roughness between the two discriminanda was considerable, well above the limits of detection described for the rat, as these experiments were not designed to test the physiological limits of discriminative ability.

Mice differed with respect to the dynamic of learning the discrimination task; about the same proportion of animals (9 mice) exhibited progressive performance improvement over several session until finally reaching the 80% correct response criterion, while in other mice performance fluctuated near a chance level until exhibiting a fairly rapid increase in performance culminating in the criterion level (7 mice). This resembles learning dynamics observed in rats during the same discrimination tasks (Guic-Robles et al. 1992).

The discrimination task used in that study can be useful for studying sensory discrimination in genetically modified mice and effects of pharmacological intervention on an advanced sensory capability.

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