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Potentiation of the transport response with supplemental stimulation in white rats

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An experiment was performed to investigate the effects of various smells combined with tactile stimulation on the transport response in white rats. Thirty-eight 16-day-old rats were lightly suspended by the nape of the neck with a spring-mechanized clothespin. They then were given a series of stimulus presentations in an attempt to induce the transport response. Results showed that gently rubbing the mother against the pup's snout or receiving a puff of water from an atomizer were effective in inducing the response. Also effective in inducing a response were having the pup's snout gently rubbed with a brush inundated with the dam's hair, being stroked with a brush inundated with dog hair, and being presented with the smell of orange extract while being brushed with a clean brush. Having the snout brushed with a clean brush with no additional stimulus did not produce a statistically reliable increase in transport-response intensity over a no-stimulus condition.

In nonprecocial animals, developing infants show varying responses to different types of environmental stimuli. These responses likely change over time, and the predominant behaviors at any one time typically will benefit the individual's survival (Spear & Ristine, 1982). In very young nonprecocial animals, these behaviors must be coordinated with the mothers' behaviors to ensure the infant's survival.

Brewster and Leon (1980) have described such an interaction between infant rats and their mothers. When a pup is grasped for transport by the mother, the pup characteristically responds by reducing its general activity (i.e., by reducing its struggling) and then actively flexes and adducts its hindlimbs and extends and adducts its forelimbs as the mother grasps the nape of its neck. The ecological value of the pup's response is that it produces a compact package for transport (Brewster & Leon, 1980).

The transport response in the infant is most effectively elicited by the mother's grasping the infant's dorsal surface, but it can also be induced by the experimenter's pinch on the infant's dorsal surface (Brewster & Leon, 1980). Wilson (1988) has reported that when a grasp or pinch on a pup's dorsal surface proves to be an inadequate stimulus in producing a strong transport response, the response may be induced or potentiated by giving the pup additional tactile stimulation in the form of an air puff, water puff, or tailpinch. Wilson (1988) proposed that the additional tactile stimulation might simulate being dragged on the ground and, thus, that the response potentiation would be adaptive in helping the mother transport the infant. Stimuli such as Wilson's (1988) have been shown to induce behavioral arousal (Antelman & Szechtman, 1975), which led Wilson, Cromey, and Kramer (1989) to propose that the transport response might be one manifestation of behavioral arousal.

Various other types of stimuli associated with the mother have been shown to induce behavioral arousal in developing rats. Pedersen and Blass (1982) reported that vigorous stroking, in a manner approximating maternal licking, can be arousing to infant rats. Likewise, Sullivan, Hofer, and Brake (1986) reported that presentation of the odor of maternal saliva to infant rats can elicit increases in behavioral activity. Finally, Hall (1979) has shown that milk delivery can produce increases in general behavioral arousal in very young rats. The experiment reported here was designed for the further investigation of the nature of stimuli that can elicit or potentiate the transport response, given an inadequate initial stimulus, in young rats. Specifically, we were concerned with whether or not stimuli associated with the mother could act to potentiate the transport response in young rats.

METHOD

Subjects

The subjects in this experiment consisted of 38 Sprague-Dawley albino rats, 16 days old at the time of testing. The litters were derived from breeding colonies in the Division of Psychology and Philosophy at Sam Houston State University and were housed with their mothers in clear Plexiglas breeding cages in a room kept at 22°C on a 12:12-h light:dark cycle with lights on at 0700 h. All testing occurred between 1000 and 1200 h.

Apparatus

An atomizer from a pump bottle of hair spray was cleaned thoroughly prior to its use in this experiment. Smells were delivered to the pups with cotton tipped swabs or fan-tail artist's brushes, as described below.

Procedure

Approximately 4 days prior to parturition, the pregnant female rats were placed in the breeding chambers, which contained nesting material.

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Each day, at 0900 and 1600 h, the cages were checked for the presence of newborn litters, with the day of birth as Postnatal Day 0. On Postnatal Day 1, litters were culled to 8–10 pups; litters containing fewer than 8 pups were not used in this experiment. On Postnatal Day 16, the dams were removed and the pups were placed in a breeding cage with fresh litter. At this point, each pup was marked with a felt-tipped pen and the mother was lightly anesthetized with 0.4 ml of Ketamine HCl. The pups then were tested singly in a separate room.

At the time of testing, the pups were grasped lightly by the skin of the nape of the neck with a spring-mechanized clothespin and suspended above the surface of a table. Since the authors were interested in investigating potentiation of the transport response in this experiment, the tension on the clothespin was adjusted to suspend the pup but to produce little, if any, transport response. The authors basically sought to produce a case of dorsal immobility in pups in this experiment. Each pup was then given the first of an individually predetermined, randomly ordered sequence of stimulus presentations with the subsequent transport-response intensity being recorded. After all the pups in the litter had been given their first stimulus presentation, the procedure was repeated until each pup had received its entire sequence of stimulus presentations. Tested in this manner, the intertrial interval of stimulus presentations for any individual animal was approximately 1.5 min. (For a detailed description of this procedure see Wilson, 1988.)

In this experiment, stimulus presentations consisted of trials of: (1) no additional stimulus; (2) the mother's snout area and vibrissae being gently rubbed against the vibrissae and snout area of the pup; (3) a fan-tail artist's brush inundated with the mother's fur being gently rubbed against the pup's snout area; (4) a brush inundated with dog hair being rubbed against the pup's snout area; (5) a clean brush being rubbed against the pup's snout area while a cotton-tipped swab inundated with orange extract was held within 1 mm of the pup's nose; (6) a clean brush being rubbed against the pup's snout area with no additional stimulation; and (7) a water puff from an atomizer being sprayed onto the snout area of the pup.

The anesthetized mother's snout was used to determine whether stimuli passively emitted from the mother might increase transport-response intensity. The brush with the mother's fur was used to determine whether the smell from the mother might be an eliciting stimulus to the pup. The dog hair and the orange extract were used to determine whether the smell from another animal or any intense smell could potentiate the transport response. The clean brush and the water puff were used to determine the effectiveness of different types of tactile stimulation in inducing the transport response in pups used in this experiment.

As a check for any gross motor impairments, all pups were given righting response tests at the end of the testing session. Also, during the course of testing, with the stimulus presentation, whether the pups struggled or not or quieted down was recorded.

Response Scoring and Data Analysis

Scoring of the responses followed the schema proposed by Brewster and Leon (1980). Each pup's response was graded on a scale of 0–5, with 1 point being awarded for each forelimb, hindlimb, and/or tail that the pup brought into contact with its ventral surface. Data were analyzed using standard parametric procedures (Kirk, 1968) with Scheffé tests used for post hoc comparisons.

RESULTS

The results from this experiment are presented in Figure 1. The data appear to show changes in transport-response intensity with tactile stimulation combined with different smells. An analysis of variance with repeated measures revealed a significant main effect for type of stimulus [$F(6,222) = 51.32, p < .05$]. Post hoc tests revealed that the atomizer produced the greatest increment in transport-response intensity, followed by having the mother gently being brushed against the pup's snout area, which was followed by being stimulated with the scent of orange extract while being brushed gently. Stimulation with a brush inundated with the mother's hair produced a reliable increase in transport-response intensity over the no-stimulus situation, as did being stimulated with a brush inundated with the dog hair. Being stimulated with a clean brush produced a transport response not different from that of the no-stimulus situation.

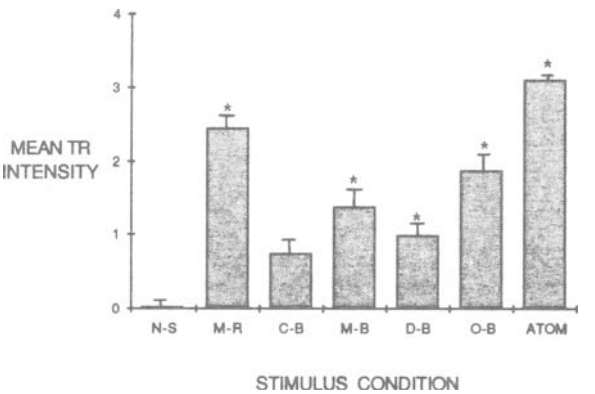

Figure 1. Transport response intensities (+1 *SEM*) as a function of nature of stimulus presentation (N-S, no stimulus; M-R, mother rubbed against the infant; C-B, clean brush against the pup; M-B, brush with mother's hair against the pup; D-B, brush with dog's hair against the pup; O-B, smell of orange extract presented with a clean brush; ATOM, atomize to the snout. The asterisks signify significant differences relative to intensities for the N-S group.

Finally, none of the pups struggled during the course of this experiment, all basically assuming a posture of dorsal immobility for the duration of time that they were suspended.

DISCUSSION

The data presented in this experiment indicate that tactile stimulation, in the form of a water puff or gentle stroking combined with addition olfactory stimulation, can produce increases in transport-response intensity in 16-day-old rats. The results from the water-puff condition are very similar to results reported by Wilson (1988), who found that various types of additional tactile stimulation can potentiate an initially weak transport response in developing rats. Wilson proposed that such stimulation may simulate being dragged on the ground when the mother does not have a firm hold on the pup's dorsal surface.

Given the variety of stimuli associated with the mother and the importance of responding to the mother's presence, it is not surprising that gently rubbing the mother against the pup's snout could produce a potentiation in transport-response intensity. Since there was only a moderate potentiation with the fur plus stroking, as compared with being brushed with the mother, the smell of the mother is apparently important but perhaps not the only important stimulus associated with the mother.

It is interesting that the tactile stimulation in the form of being gently stimulated with a clean brush did not produce increments in transport-response intensity. If one assumes that the transport response is a manifestation of behavioral arousal, however, a quick water puff might be more surprising than a gentle stroking. When this tactile stimulation was combined with various smells, though, increments in transport-response intensity occurred. The type of olfactory stimuli is interesting, in that the orange scent produced a very large increment in transport-response intensity, followed by stimuli in the form of mother's hair,

followed by the smell of dog hair. As mentioned above, stimuli associated with the mother may help potentiate the transport response in developing rats. The dog hair was used to see if the smell from any animal might result in transport-response potentiation. Even though the dog hair produced an increase in transport-response intensity above that of the no-stimulus control condition, this increase was not different from the clean brush condition. Thus, one might assume that smells from other animals are less important to the pup. In fact, in the wild it may even be detrimental to show a strong transport response in the presence of certain stimuli, for this might help a predator carry the pup away.

Gently brushing the pup combined with the smell of orange extract produced a large increment in transport-response intensity. Wilson et al. (1989) has proposed that the transport response may be a manifestation of specific behavioral arousal, as suggested by Szechtman and Hall (1980). If one assumes that the transport response is linked to behavioral arousal, perhaps the novelty of the smell or the intensity of the smell produced arousal in the pups that, when combined with the gentle stroking of the pup's snout area, was channeled into a transport response. Perhaps the novelty of the smell of the dog also produced arousal that was channeled into a transport response when combined with the tactile stimulation of being brushed.

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