PAN
POLSKA AKADEMIA NAUK

Original Papers

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The effects of handling on the exploratory activity of rats in settings varying in level of sensory stimulation[1]

This study tests the assumptions of need for stimulation theory. According the main hypothesis of this theory, the stimulus seeking activity of an organism in an unfamiliar environment is affected by two main temperamental traits: emotional reactivity and need for stimulation. In a familiar setting, the influence of emotional reactivity disappears, while the need for stimulation persists. Two experiments were run in which animals' emotionality was manipulated by means of presence or absence of handling and the level of environmental stimulation was manipulated by varying the intensity of light to which the animals were exposed. Sixty male Wistar rats were tested in the first experiment. Stimulus seeking activity was registered in the Skinner-type chambers where animals could switch the light on by every head dip into one of two holes, the so-called experimental hole. Animals were tested in five 30-minute sessions repeated every 48 hours. As predicted, the effect of emotionality on exploration emerged at the beginning of the experiment (handled rats demonstrated a stronger preference for the experimental hole), whereas the effect of the level of environmental stimulation on the total number of head-dips emerged in all the experimental sessions. The second experiment involved 40 rats and followed a similar design, but the stimulus seeking activity was measured in the situation where the animals could switch the light off by dipping their heads into the experimental hole. Contrary to predictions, the experimental factors had no significant effect on the animals' stimulus seeking activity. Only the results of the first experiment confirm the assumptions of need for stimulation theory.

Keywords: stimulus seeking behavior, self-exposure of light stimuli, handling

Introduction

Exploratory behaviour is a very heterogeneous category of activity. According to one of the major attempts to classify it, exploratory behaviour can be grouped into behaviour manifested in novel environment or in response to novel stimuli and behaviour manifested in familiar and stable environments. This distinction was reflected in early theories of exploratory motivation positing the existence of a curiosity drive which fuels exploratory behaviour in the face of novel stimuli (Montgomery, 1951) and a boredom drive which instigates activity when the stimulus field remains unchanged (Myers & Miller, 1954). Berlyne's concepts of specific exploration and diversive exploration (Berlyne, 1966) also reflect this distinction. It follows from these examples that exploratory activity in new versus familiar environments is assumed to be differently motivated.

One of the theories which offers to explain the motivational dynamics of exploratory behaviour in novel versus familiar settings is need for stimulation theory (Matysiak, 1992; Pisula & Matysiak, 1998). This theory rests on the assumption that when the organism comes into contact with novel stimuli, it enters the informational phase of stimulus seeking activity. In this phase the intensity of exploratory behaviour is determined by two temperament traits, emotional reactivity and need for stimulation. The importance of emotional reactivity is a function of the emotogenic nature of novel stimuli. The importance of need for stimulation flows from the mechanism postulated by Hebb (1955), whereby an optimal level of arousal in the central nervous system is maintained. In the informational phase the organism reconnoitres the effects of its reactions on the stimulus field. The moment it has completed the process of distinguishing among different stimulus-

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producing reactions, i.e., those which affect the amount of stimulation, and neutral reactions, the environment ceases to trigger emotions and the organism proceeds to the regulative phase in which need for stimulation is the predominant feature. In this phase exploration gives way to instrumental reactions which regulate the influx of stimulation.

The division of stimulus seeking behavior into distinct phases posited by need for stimulation theory resembles Berlyne's (1966) distinction between specific and diversive exploration. Specific exploration provides information on specific novel and complex stimuli. Hence, specific exploration could be the equivalent of exploratory behavior during the informational phase. Diversive exploration (behavior that is not focused on any particular object, e.g. motor exploration), in turn, ensures an optimal level of stimulation (e.g. the organism can approach or move away from the source of the stimulus). Therefore it could be seen to correspond with stimulus seeking behavior of the regulative phase. However, these two concepts are not entirely parallel. First of all, exploratory activity in Matysiak's theory is random and diffusive rather than clearly focused, although the necessary condition for it to occur is stimulus novelty. The regulative phase activity, in turn, although it provides an optimal level of stimulation, is not as „diversive", since the organism's responses are directed towards specific sources of stimuli (Matysiak, 1992).

Although the theory of need for stimulation is empirically based (Zawadzki, 1992; Pisula, Ostaszewski & Matysiak, 1992; Matysiak, Ostaszewski & Pisula, 1995; Ostaszewski, Pisula and Watras, 1992), its assumptions have not yet been submitted to direct experimental testing.

To test the assumptions of the theory of need for stimulation empirically it is necessary to: (1) manipulate the emotogenic effect of sensory stimulation on the organism; (2) manipulate the arousal function of stimulation; (3) register stimulus seeking activity for as long enough a period to ensure that the regulative phase has begun. We conducted two experiments which met these requirements. Their purpose was to verify the hypotheses that: (1) when the organism comes into contact with novel stimuli, its stimulus seeking activity is determined by emotional reactivity and need for stimulation; (2) in a familiar environment, stimulus seeking activity is determined by need for stimulation.

To manipulate emotional characteristic of the experimental animals we used the handling procedure. The most frequently reported effects of handling in rats are reduced number of defecations and increased exploratory activity (Aulich, 1976; Ardila, Rezk, Polanco & Pereira, 1977; Caldji et al., 2000; File, 1978; von Hoersten, Dimitrijevič, Markowič & Janković, 1993; Rebouças & Schmidek, 1997; Schmitt & Hiemke, 1998; Wild & Hughes,

1972; Thompson & Lippman, 1975). Such changes in animal activity are usually interpreted in terms of reduced emotionality. This opinion has been confirmed by findings that that handling reduces hypothalamic-pituitary-hormonal activity (Caldji et al., 2000; Lehmann et al., 2002; Núñez, Ferré, Escorihuela, Tobeña and Fernández-Teruel, 1996; Vallée et al., 1997).

It is easy to control the arousal function of stimulation. In the present study we manipulated the intensity of light stimuli exposed in the experimental chambers.

Since the regulative phase of activity occurs only after the animal has spent a certain amount of time in the unfamiliar setting, in the present study we decided to use five brief 30-minutes repeated measures.

Several predictions concerning the effects of the factors mentioned above on stimulus seeking activity follow from need for stimulation theory: (1) the effect of emotionality will only show up in early stages (in the third session at the latest) of the experiment, i.e., when the environment is unfamiliar; (2) the effect of intensity of the sensory stimulation will show up in all stages of the experiment. In other words, the effects of emotionality and stimulus intensity or interaction of the two on the level of stimulus seeking activity should occur in early measures. In later sessions only stimulus intensity should have a significant effect on stimulus seeking behavior whereas emotionality should not.

To measure stimulus seeking activity we used a method introduced by Girdner (1953, cited in Kish, 1966), involving self-exposure of light stimuli. Measuring exploratory activity by means of a bar in a Skinner-type chamber may arouse controversy, however. Zuckerman (1984), for example, thought that the choice of so artificial a response as bar pressing renders it impossible to embrace the natural interplay of behavior and environment. In the case of exploratory behavior, such interaction seems to be particularly important. Pressing a bar is not part of the natural behavioral repertoire of rats. We therefore used holes instead of bars. Rather than pressing a bar, the rats could explore a hole (by inserting their noses or heads). This solution has at least two advantages. First, head-dipping is a rat's natural, spontaneous form of behavior. Second, as a measure of exploratory behavior it has sufficient face validity since it probably involves information gathering.

Experiment 1

In the first experiment, manipulation involved the presence or the lack of handling and a differentiation of the intensity of light exposed to the animals. The purpose of this experiment was to determine the effects of emotionality and the need for stimulation on the stimulus seeking activity of rats in a setting where the animals were given the opportunity to expose themselves to light stimuli.

Materials and methods

Subjects

The experiment was run on 60 experimentally naïve male Wistar rats, about 100 days old. The rats were brought to the laboratory when they were three weeks old. They were reared in artificial day-night conditions (light on at 8 AM and off at 8 PM). The room temperature was kept at approximately 21°C. Animals were housed in wire cages, five subjects per cage. Food and water were available ad lib.

Apparatus

Six Skinner-type self-exposure chambers measuring 33x30x27 centimeters were used to register stimulus seeking activity. The sides of the chambers were made of aluminum and the fronts and backs were made of Plexiglas. The floor was made of parallel metal rods. The ceilings, made of matt Plexiglas, were equipped with six 1.5 Watt electric bulbs. Each of the side walls had a single round hole, 3 centimeters in diameter, situated 10 centimeters above floor level. Each hole was equipped with a photocell. A special computer program developed at our laboratory controlled the operation of the chambers. This software registered the number of head-dips into each hole.

Procedure

Half of the animals (30 rats), selected at random, were handled. Handling terminated one week before the experiment began. Handling consisted of the following procedure: each rat was transferred (separately) by hand from its home cage to another cage of identical dimensions and then back again to the home cage. For the first week after arrival at the laboratory the rats were handled daily then, for the next two weeks they were handled three times a week and commencing from the fourth week they were handled twice a week.

Two weeks before the experiment proper the rats were pre-tested to determine their level of stimulus seeking activity. The pre-test involved a single, 30-minute registration of activity in the self-exposure chambers where every fourth insertion of the head (so-called head-dipping reaction) into one or other hole switched on a light of 2 lx intensity (measured at floor level) for 3 seconds. The total number of head-dipping reactions into both holes was the measure of stimulus seeking activity. On the basis of the pre-test results the handled and non-handled groups were divided into three equinumerous subgroups balanced for number of head dipping reactions. There were 6 subgroups, 10 rats per group.

In the experiment proper all subgroups were tested in the self-exposure chambers for stimulus seeking behavior. Testing took place in five 30-minute sessions every 48 hours in a completely dark and silent room between 3 and 6 PM. The chambers were not cleaned in the course of the experiment. The light was switched off in the chambers as well. In the first session, head-dipping into the holes in the side walls of the chambers did not alter the experimental environment, i.e., did not switch on the light, i.e., the experimental setting was the same for all animals. In subsequent sessions the experimental subgroups (which cut across the handled and nonhandled groups) were tested in three different settings: low, moderate and high level of light environmental stimulation. Stimulation intensity was controlled by modifying the intensity of light (5, 11 or 27 lx) which was turned on for 3 seconds the moment the animal produced a head-dipping response into one of the two holes in the wall. Each head-dipping response into that hole (the experimental hole) turned on the light which intensity was predetermined according to the experimental design. Head-dipping responses into the other (control) hole did not alter the environment in any way. In one half of the chambers the experimental hole was located on the right side, and in the other half – on the left. The criteria for selecting the intensity of light were as follows. The lowest intensity had to be easily perceptible for the human eye. The medium intensity was the same as that used in the rats' home cages. The most intense light was to be easily distinguishable from the medium intensity light, but not as strong as to become a clearly aversive stimulus. The experiment was balanced for the chambers.

During the experiment a computer registered the number of head-dipping responses to the experimental *(Ne)* and control *(Nc)* holes, session by session.

Results

A two-factor ($2_{handling}$ x $5_{session}$) and three-factor ($2_{handling}$ x $3_{light\ intensity}$ x $5_{session}$) ANOVA was performed. The first analysis covered all five sessions but only two experimental factors, "handling x session". The third factor, "light intensity" was excluded from this analysis because it was not manipulated in the first session. In the second analysis all three experimental factors (handling x light intensity x session) were considered. Session one was excluded for the aforementioned reasons. The following behavioral scores were submitted to statistical analysis: (1) total number of head-dips *(Nt=Ne+Nc)*; (2) the ratio of head-dips into the experimental hole to the total number of head-dips into both holes *(NS=Ne/Nt)*, need for light stimulation index; (3) number of alternations of choices between holes *(Na)*. The variables were submitted twice to ANOVA.

The analysis performed for five sessions revealed a main effect of session for the following scores: $Nt - F_{(4, 232)}=38.358$, $p<0.001$ (Fig. 2); $Na - F_{(4, 232)}=21.999$, $p<0.001$. As far as total number of head-dips is concerned, the contrast test revealed a significant difference between sessions one and two, $F_{(1,58)}=76.228$, $p<0.001$, one and three, $F_{(1,58)}=57.746$, $p<0.001$), one

Table 1
Means and standard deviation values for handled and non handled rats in all sessions of Experiment 1.

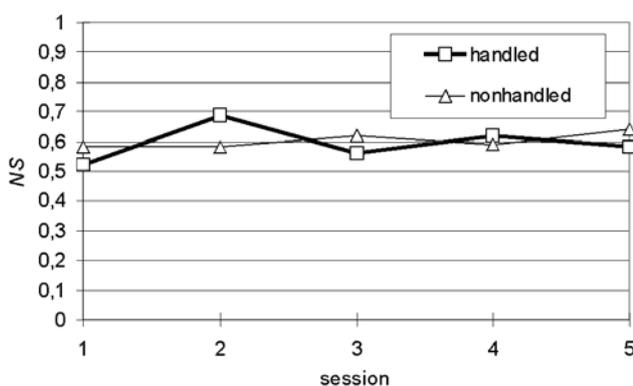|	Total number of head-dips									
	Session 1		Session 2		Session 3		Session 4		Session 5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Handled rats	5.62	2.27	14.13	6.92	12.17	5.81	15.44	6.34	12.82	7.67
Non handled	6.38	2.80	14.96	7.37	13.51	6.76	12.90	5.47	13.00	5.27
	Ratio of head-dips into the experimental hole to the total number of head dips									
Handled rats	0.52	0.18	0.69	0.13	0.55	0.12	0.62	0.12	0.57	0.13
Non handled	0.58	0.14	0.57	0.15	0.61	0.13	0.59	0.14	0.64	0.15
	Number of alternations									
Handled rats	2.58	1.32	4.41	2.42	5.48	3.39	6.75	3.57	5.82	3.54
Non handled	2.87	1.54	5.22	2.70	5.64	2.98	5.41	3.18	5.61	3.19

Figure 1. Mean values of need for stimulation index -NS (the ratio of the number of head-dips into the experimental hole to the total number of head dips into both holes) in Experiment 1.

and four, $F(1,58)=97.213$, $p<0.001$ and one and five, $F(1,58)=62.866$, $p<0.001$). Differences between session one and the remaining sessions were also found for number of alternations: sessions one and two, $F(1,58)=33.393$, $p<0.001$, one and three, $F(1,58)=39.577$, $p<0.001$, one and four, $F(1,58)=55.301$, $p<0.001$) and one and five, $F(1,58)=45.938$, $p<0.001$. In all these cases the effect of session was as follows: the mean values of the scores were lower in session one than in the remaining. The analysis did not reveal a main effect of session for NS, $F(4,232)=2.154$, $p>0.05$.

The analysis did not reveal a main effect of handling neither for Nt, $F(1,58)=0.01$, $p>0.05$, nor for Na, $F(1,58)=0.012$, $p>0.05$. There was not an effect of interaction between session and handling for above indices (respectively $F(4,232)=1.875$, $p>0.05$ and $F(4,232)=1.973$, $p>0.05$). As far as score NS is concerned there was not a main effect of handling, $F(1,58)=0.163$, $p>0.05$, but an interaction between session and handling was found, $F(4,232)=4.797$, $p<0.001$ (Fig. 1). For the handled rats the contrast test showed that there was a significant difference between sessions one and two, $F(1,38)=17.133$, $p<0.001$, and sessions one and four, $F(1,38)=10.027$, $p<0.005$). No differences among sessions were found for the

nonhandled rats. In addition, one-way ANOVA for single sessions revealed a main effect of handling in session two, $F(1,54)=8.018$, $p<0.01$ and session three, $F(1,54)=4.712$, $p<0.05$) with the handled rats having higher NS scores in session two and the nonhandled rats having higher NS scores in session three. The descriptive statistics are reported in Table 1.

Analysis of variance for four sessions (from session two to five) including the third factor, i.e., light intensity, revealed no interactions between this factor and session (for Nt: $F(6,162)=1.154$, $p>0.05$, for Na: $F(6,162)=0.920$, $p>0.05$, for NS: $F(6,162)=0.591$, $p>0.05$) and handling (for Nt: $F(2,54)=1.037$, $p>0.05$, for Na: $F(2,54)=2.038$, $p>0.05$, for NS: $F(2,54)=1.113$, $p>0.05$). It did, however, yield a significant main effect of light intensity on total number of head-dips , $F(2,54)=14.481$, $p<0.001$) and number of alternations, $F(2,54)=9.614$, $p<0.001$. As far as these two scores are concerned, in all sessions, the animals were less active when the light had an intensity of 5 lx than when the light had an intensity of 11 lx. There was no effect of light on NS, $F(2,54)=2.838$, $p>0.05$. The descriptive statistics are reported in Table 2.

Discussion

In accordance with need for stimulation theory it was predicted that if we manipulated animal emotionality this would have an effect on stimulus seeking activity only in the early sessions of the experiment whereas if we manipulated the intensity of sensory stimulation this should affect the rats' activity in all sessions in which this manipulation was present (sessions 2-5). The significant handling x session interaction effect on the Ne/Nt ratio is consistent with this prediction. The fact that the effect of handling (i.e., the animals' emotional characteristics) on head-dipping occurred only in the early stage of the experiment (i.e., in relatively novel environment) is consistent with the assumption of Matysiak's theory concerning the importance

Table 2

Means and standard deviation values for handled and non handled rats in sessions 2-5 of Experiment 1 in three light conditions (5, 11 and 27 lx).

	Session 2		Session 3		Session 4		Session 5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total number of head-dips								
5 lx								
Handled rats	8.70	3.56	7.80	4.13	10.00	5.33	7.50	2.06
Non handled	9.90	4.48	10.20	4.10	9.60	3.06	11.60	3.89
11 lx								
Handled rats	19.80	5.39	15.90	4.45	20.10	3.81	17.40	8.55
Non handled	19.11	7.97	15.00	4.15	14.66	5.24	15.11	6.90
27 lx								
Handled rats	13.88	6.62	12.88	5.90	16.33	5.24	13.66	7.53
Non handled	16.08	6.85	15.16	9.14	14.33	6.27	12.58	4.83
Ratio of head-dips into the experimental hole to the total number of head dips								
5 lx								
Handled rats	0.74	0.15	0.58	0.19	0.67	0.13	0.56	0.15
Non handled	0.57	0.12	0.65	0.12	0.55	0.21	0.66	0.15
11 lx								
Handled rats	0.69	0.11	0.56	0.13	0.58	0.12	0.58	0.13
Non handled	0.65	0.17	0.60	0.12	0.62	0.10	0.67	0.13
27 lx								
Handled rats	0.63	0.13	0.52	0.12	0.61	0.12	0.57	0.12
Non handled	0.52	0.15	0.59	0.13	0.60	0.12	0.58	0.16
Number of alternations								
5 lx								
Handled rats	2.50	1.84	3.00	1.76	3.80	2.25	3.40	1.34
Non handled	4.10	1.72	4.60	1.17	4.20	1.75	4.80	2.69
11 lx								
Handled rats	6.10	2.51	7.30	2.49	8.60	3.27	7.80	3.39
Non handled	5.66	2.82	6.22	2.77	4.88	2.61	6.66	4.00
27 lx								
Handled rats	4.66	1.22	6.22	4.17	8.00	3.16	6.33	4.06
Non handled	5.83	3.15	6.08	4.01	6.83	3.95	5.50	2.93

of emotional mechanism for the regulation of exploratory behavior. In turn, the light intensity factor influenced total number of head-dips in all the sessions in which this variable was manipulated, just as predicted.

These findings do not fully reflect the dynamics of stimulus seeking behavior posited by the theory, however. Drawing upon the findings of Zawadzki (1992), Matysiak has assumed that in the information gathering phase, when stimulation has an emotogenic effect on the organism, this activity should be diffusive and haphazard because the organism has not yet discovered the connection between its own behavior and environmental change (Matysiak, 1992). In the self-exposure chamber this is reflected in the random distribution of experimental and control bar presses (or head-dips). In the regulative phase, on the other hand, stimulation no longer arouses emotions and

behavior becomes more organized, i.e., reactions of which consequences the organism is aware take the stage. In the self-exposure chamber this is reflected in the different numbers of experimental and control bar presses (or head-dips). Meanwhile, our results suggest that in the phase where stimulation had an emotion arousing effect the rats' activity was definitely not diffusive. In session two the less "emotional" handled rats directed nearly 70% of their activity to the experimental hole. The value of *NS* diminished in subsequent sessions and was in the .55-.65 range. We had not a control group where head-dips did not alter experimental environment but considering that sensory reinforcement was not introduced until session two, and drawing upon the findings of other researchers (Kish, 1966; Lowe & Williams, 1968; Wells, Williams & Lowe, 1971; Zawadzki, 1992), we may speculate that

the factor responsible for the greater attractiveness of the experimental hole at that time was the novelty of the animals' reaction outcomes. Recognition of the stimulating consequences of one's own responses need not imply that these consequences no longer have the lure of novelty.

Our findings lend themselves to the hypothesis that exploratory activity may be haphazard and diffusive in completely novel environments but becomes focused on specific novel stimuli once these stimuli begin to appear among other, familiar stimuli. Renner and Seltzer (1991) obtained data supporting this hypothesis in their exploration test constructed on the basis of the open field test. They placed several objects in their apparatus. After 14 days in an unaltered setting, new objects were introduced. The results showed that the introduction of new objects resulted in fewer interactions with familiar objects. Furthermore, the changes in the activity of the animals caused by the introduction of new objects had more impact on the interactions with objects than on the general activity (locomotion, rearings). Seltzer's study notwithstanding, this hypothesis needs to be empirically tested in the self-exposure chamber because it is uncertain whether new objects and new reaction outcomes represent the same category of novelty. Results similar to Renner's were obtained by Pisula (2003) . Rats responded to change of object configuration with increased duration of object contact and decreased walking. Animals' activity was clearly focused on novel stimuli. This principle was also reported by Hughes (2001). In his study rats first entered the arm of T- or Y-maze of which brightness had been changed, entered this arm more often and spent more time in it than in unchanged arm. Also the results obtained by Besheer and Bevins (2000) on the role of environmental familiarization in novel-object preference can be interpreted in similar way.

Earlier researchers have found that emotionality affects total number of bar presses in the self-exposure chamber but not the ratio of experimental bar presses (resulting in the change in lighting) to the total number of presses of the experimental and control bars (Ostaszewski et al., 1992; Matysiak et al., 1995). In the present study we actually found a reversed relationship, i.e., handling had a significant effect on the *Ne/Nt* ratio but not on total number of head-dips. This finding may seem rather surprising at first. It follows from the results of research on light reinforced bar pressing that the novelty of stimulus (hence its affective value) affects its reinforcing value (Kish, 1966). Thus we can hypothesize that in session two the emotogenic influence of novel stimuli was sufficient for handling to affect acquiring instrumental responses but not to affect total number of head-dips. However, in session one, when the environment was completely new and the most emotogenic, effect of handling on total number of head-dips did not occur also. This result may be due to the low scores observed for this measure, which is probably the consequence of the anxiety induced by the unfamiliar setting.

The effects of manipulating light intensity on total number of head-dips and number of alternations may pose interpretative problems. Surprisingly, manipulation of the energy value of sensory reinforcement had just the same effect on stimulus producing responses as it did on neutral responses. Need for stimulation probably did not, therefore, moderate this effect. The lack of any significant effect of light intensity on activity measured in terms of need for light stimulation index (*NS*) is inconsistent with earlier findings (Matysiak, 1980).

Experiment 2

The purpose of the second experiment was to determine the effects of emotionality and intensity of sensory stimulation on rat activity when the animals could actively avoid light stimulation.

Materials and methods

Subjects
The experiment was run on 40 male Wistar rats, about 100 days old.

Apparatus
Stimulus seeking activity was measured using identical self-exposure chambers to the ones which were used in Experiment 1.

Procedure
The experimental procedure was similar to the one adopted in Experiment 1. There was one basic difference, however. The self-exposure chambers operated in the OFF mode, i.e., head-dipping into the holes switched off the light. Also, the procedure was simplified on the basis of experience gained in Experiment 1. Only two light intensities were used and therefore there were four subgroups, 10 rats per group.

During the experiment proper, in all sessions, the chambers were lit with predetermined intensity, either 5 lx or 27 lx. When selecting the highest and lowest intensity of light used in the first experiment, we assumed that the animals should be the least intent on switching off the low intensity and most intent on switching off the high intensity light. In session one, head-dipping into the holes did not alter the experimental setting. In subsequent sessions every head-dipping response into the experimental hole turned off the light for 3 seconds. A three-factor ANOVA involving $2_{handling}$ x $2_{light\ intensity}$ x $5_{session}$ was performed.

Table 3
Means and standard deviation values for handled and non handled rats tested in two light settings (5 and 27 lx) in Experiment 2.

	Session 1		Session 2		Session 3		Session 4		Session 5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total number of head-dips										
5 lx										
Handled rats	23.80	9.43	21.40	10.13	14.20	6.28	15.10	4.74	14.20	5.80
Non handled	13.90	7.40	19.30	6.51	13.40	8.65	13.80	7.00	8.40	4.40
27 lx										
Handled rats	15.60	9.31	21.90	7.35	17.20	7.06	13.80	8.58	11.90	4.09
Non handled	13.20	2.97	20.00	7.57	14.20	5.43	15.10	4.99	9.90	3.38
Ratio of head-dips into the experimental hole to the total number of head dips										
5 lx										
Handled rats	0.50	0.11	0.46	0.12	0.49	0.12	0.47	0.10	0.46	0.12
Non handled	0.44	0.06	0.53	0.12	0.43	0.15	0.46	0.16	0.49	0.12
27 lx										
Handled rats	0.46	0.14	0.52	0.09	0.48	0.09	0.45	0.09	0.51	0.10
Non handled	0.49	0.10	0.55	0.09	0.55	0.12	0.49	0.13	0.49	0.12
Number of alternations										
5 lx										
Handled rats	7.20	1.54	7.60	2.63	5.70	3.09	6.00	3.55	5.90	2.72
Non handled	5.20	1.47	6.60	2.83	5.50	2.83	5.00	2.40	3.30	2.00
27 lx										
Handled rats	4.60	2.06	7.10	2.13	7.20	2.39	5.70	2.05	4.50	1.95
Non handled	4.60	1.17	7.10	2.99	5.30	1.94	6.00	2.62	4.20	1.54

Results

The following behavioral scores were submitted to statistical analysis: (1) total number of head-dips (Nt); (2) the ratio of head-dips into the experimental hole to the total number of head dips into both holes, need for light stimulation index (NS); (3) number of alternations of choices between holes (Na).

A three-factor ANOVA revealed a main effect of session on total number of head-dips, $F(4,144)=17.091$, $p<0.001$) and on number of alternations, $F(4,144)=8.191$, $p<0.001$). For total number of head-dips the contrast tests revealed significant differences between sessions one and two, $F(1,36)=8.277$, $p<0.01$ and sessions one and five, $F(1,36)=8.422$, $p<0.01$ (Fig. 2). For number of alternations the contrast tests revealed significant differences between sessions one and two $F(1,36)=14.758$, $p<0.001$ and sessions one and five $F(1,36)=8.422$, $p<0.01$. On both variables the animals were less active in session one than in session two and more active in session one than in session five. There was no effect of session on the Ne/Nt ratio, $F(4,144)=0.802$, $p>0.05$.

The analysis did not reveal a main effect of light intensity (for Nt: $F(1,36)=0.091$, $p>0.05$, for Na: $F(1,36)=0.135$, $p>0.05$, for NS: $F(1,36)=2.272$, $p>0.05$) and handling (for Nt: $F(1,36)=3.213$, $p>0.05$, for Na: $F(1,36)=3.538$, $p>0.05$, for NS: $F(1,36)=0.605$, $p>0.05$). No significant effect of interaction neither between session and light intensity (for Nt: $F(4,144)=1.998$, $p>0.05$, for Na: $F(4,144)=1.719$, $p>0.05$, for NS: $F(4,144)=0.270$, $p>0.05$) nor between session and handling was found (for Nt: $F(4,144)=1.901$, $p>0.05$, for Na: $F(4,144)=0.451$, $p>0.05$, for NS: $F(4,144)=0.441$, $p>0.05$). There was not significant effect of interaction between light intensity and handling (for Nt: $F(1,36)=0.584$, $p>0.05$, for Na: $F(1,36)=1.122$, $p>0.05$, for NS: $F(1,36)=1.185$, $p>0.05$). The descriptive statistics are shown in Table 3.

Discussion

Numerous research findings have suggested that not only the switching on of light but also its switching off in the Skinner box serves as a reinforcement (Berlyne, Koenig & Hirota, 1966; Goodrick, 1970; Matysiak, 1980). Hence, theoretically at least, both variants of sensory reinforcement can be used as equivalent methods in stimulus seeking studies. Our use of the OFF mode self-exposure chamber allowed us to test the effects of the "light intensity" factor in session one without simultaneously introducing sensory reinforcement. We were thus able to simplify the statistical analysis.

The analysis including repeated measures did not show any effect of handling and light intensity on stimulus seeking behavior. Our results therefore do not support need for stimulation theory.

General discussion

According to need for stimulation theory, two dispositional variables affect stimulus seeking behavior in the face of novel stimuli: emotional reactivity and need for stimulation. Eventually, as novelty wears off, it ceases to trigger emotions and emotional reactivity ceases to regulate stimulus seeking behavior, giving way to need for stimulation which becomes the main regulating factor. Our study tested these theoretical assumptions.

In the first of our two experiments rats were tested in ON mode self exposure chambers where they could supply themselves with stimulation by switching on the light. In the second experiment an OFF mode setting was arranged. The self-exposure chamber was lit and the rats could avoid stimulation by switching off the light. Our expectation was that the postulated effect of the experimental factors on stimulus seeking behavior would show up in both experiments.

The results were equivocal, however. Experiment one supported the assumptions of need for stimulation theory: the effect of emotional reactivity was observed in the case of the ratio of head-dips into the experimental hole to the total number of head-dips in the early phase of the experiment only, whereas stimulus intensity affected total number of head-dips throughout the whole experiment. Contrary to predictions, the experimental factors had no significant effect on the animals' activity measures in the second experiment.

Differences in the ON and OFF procedures may be responsible for our equivocal results. According to need for stimulation theory animal activity in the ON and OFF chambers is probably motivated in the same way (Matysiak, 1992) – animals are interested in maintaining the optimum level of arousal in the central nervous system. However the results of studies shows that as long as the stimuli provided are not too intensive, the opportunity to switch on the source of stimulation is more attractive than the opportunity to switch it off (Kish, 1966).

If we compare the dynamics of the rats' total number of head-dips in experiments one and two (Fig. 2), we see that the settings had different effects on the animals' behavior. In the second session, when we introduced the contingency between the animals' behavior and light stimuli, the rats' activity increased whichever experiment we consider. However, whereas this heightened activity persisted until the end of experiment one, it was limited only to the session in which the contingency was introduced in experiment two. Having compared the procedures and outcomes of our two experiments we can now say that differences in
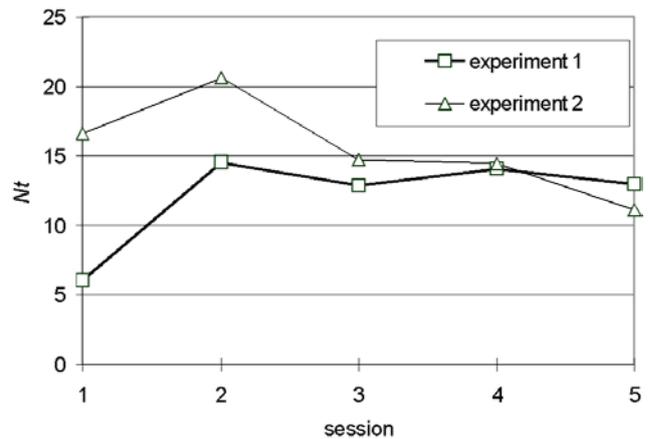

Figure 2. Mean total number of head-dips (Nt) dynamics in Experiment 1 and Experiment 2.

the ON and OFF procedures can be held at least partly responsible for the ambiguity of our findings. In an earlier study (Matysiak, 1980) which used both those methods, we found a correlation between the stimulus seeking activity of rats in the ON and in the OFF mode. It is therefore possible that we chose the wrong intensity of light in the second experiment.

To conclude, we may say that as far as first experiment is concerned, our results are consistent with the assumptions of need for stimulation theory. Emotional processes (emotional reactivity) play a significant role in the regulation of stimulus seeking behavior in a novel environment. They do not, however, have any effect on stimulus seeking activity in a familiar environment. This is a very interesting finding. Although numerous studies of emotionality and exploration have been conducted, only a few researchers have followed this relationship over a longer period of time when habituation of the emotional responses to the novel environment would be expected to have set in (e.g., Dalrymple-Alford & Benton, 1981; Gentsch, Lichtsteiner and Feer, 1991). The results of Experiment 1 prove that descriptions of mechanisms that regulate exploratory behavior should take into account emotions. Cognitive theories that focus on attention (e.g. Inglis, 1983) overlook that aspect of the organism's functioning. Those theories assume that the exploratory drive should be aroused by stimuli that are other than expected. However, they ignore the fact that such stimuli may in fact produce emotions that can in turn inhibit at least some forms of exploration.

In first experiment we have also managed to support the hypothesis concerning the effect of the intensity of stimulation on the regulation of stimulus seeking behavior. We have not managed to confirm theoretical assumptions concerning the role of need for stimulation understood as a trait which manifests itself in active regulation of the amount of sensory stimulation.

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